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Consortia optimization for European Space Agency proposals based on cognitive computing

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ABSTRACT

This master thesis intends to study relations between the words written in European Space Agency (ESA) Invitation to Tender (ITT) abstracts, and, if there is any correlation between the words and the chance of a certain country to award a bid.
An intermediate task was to compile and organize a proper dataset. A dataset was created using the ESA Dashboards and ESA Emits from 2013 to 2016 as basis.
Then, we developed the necessary codes to analyze this dataset in R.
We constructed matrices and graphical representations with the relations between Winner Countries, the ESA Offices and the different ESA Programs. Based on this, our firsts points were raised and analyzed.
Five countries were selected based in the number of awarded ITTs. They are Germany, France, Great Britain, Italy and Belgium. These countries were scrutinized using text mining techniques and statistics models.
Using our dataset, we analyzed the entire text abstract with R packages for text mining, as the TM package. The original abstracts were organized removing numbers, white spaces and most frequent words. After these steps, document term matrix (DTM) were constructed. DTM is a matrix, where the rows are the documents (ITT abstract) and the columns are the variables (most frequent words). The DTM was the basis for all textual analysis study. Regression models (logistic regression) were created for these five countries and stepwise methods used for variables selection. The created models relate words with the chance of a certain country winning an ITT.
The validity of the models was analyzed using statistics parameters as: Sensibility x Specificity curve (cut-off point), Area under ROC curve, ODD.Ratio and fitted values.
Afterwards, we started to investigate if the ITTs clustered in the DTM defined space. Different methods were used to define clusters. We verified if clustered formed in the word frequency space and also in a principal component analysis transformed space. However, results show that no method results in an automatic clustering using the Silhouette method, suggesting that more advanced techniques might be needed to extract the true number of clusters. The results of the application of PCA do not show agglomeration, suggesting internal clustering tendency.
Finally, we can conclude that there seems to exist some relations between words and winner countries, the reasons for which remains to be studied in further works.

KEY-WORDS: ESA, text mining, R, DTM, logistic regression, stepwise methods, ITT, winner country, clusters, Kmeans, PCA

RESUMO

Esta tese de mestrado estuda as relações entre as palavras escritas nos resumos dos concursos da Agência Espacial Europeia(ESA - Invitation to Tender - ITT) e, em particular, se existe alguma correlação entre as palavras e a possibilidade de determinado país ser o ganhador do concurso.
Um conjunto de dados de 2013 a 2016, com as informações dos dashboards dos status dos concursos e as informações do site Emits fornecidos pela ESA foram organizadas e compiladas.
Em seguida, os códigos necessários para analisar esse conjunto de dados foi desenvolvido em R.
Construimos matrizes e representações gráficas com as relações entre os países vencedores, os escritórios da ESA e os diferentes programas da ESA. Com base nisso, os primeiros pontos foram levantados e analisados.
Em seguida, selecionamos cinco países com base no número de ITTs premiados e representatividade nos escritórios da ESA para desenvolvimento de modelos estatísticos. Esses países são: Alemanha, França, Grã-Bretanha (Reino Unido), Itália e Bélgica.
Com o uso de pacotes de mineração de dados (text mining), com o "TM" do R, os resumos originais foram organizados, de forma a retirar informação irrelevante que poderiam dificultar a realização deste trabalho. Números, espaços em branco e palavras mais freqüentes foram removidas e todo texto foi colocado em minúsculo. Após estas etapas, a matriz documento por termo (DTM) foi construída. Nesta matrix, cada linhas é um documento (neste caso, o resumo de cada um dos ITTs) e cada coluna as variáveis (neste caso, as palavras mais frequentes na base de dados). A DTM é a base de todo o estudo relativo a análise textual. Para cada um dos cinco países com mais ITTs, modelos logísticos foram criados e métodos de seleção Stepwise aplicados. Os modelos criados relacionam palavras com a possibilidade de um determinado país ganhar um ITT. A validade dos modelos foi analisada utilizando parâmetros estatísticos como: sensibilidade x curva de especificidade (ponto de corte), área curva Roc e Odd.
Posteriormente, começamos a investigar se os ITTs se aglomeraram em clusters definidos por estas variáveis. Diferentes métodos foram utilizados. O parâmetro da silhueta foi usado para validação dos clusters, porém os resultados não foram satisfatórios. Aplicou-se a análise de componentes principais (PCA), que permaneceu deixando lacunas, sugerindo que estudos mais avançados devem ser feitos para entender essa questão.
Com este estudo, podemos inferir que existem relações entre as palavras escritas nos resumos dos ITTS e a chance de um determinado país ser o vencedor de um determinado ITT. Por essa razão, este tema merece continuar a ser desenvolvido em trabalhos futuros.

PALAVRAS-CHAVE: ESA, text mining, R, DTM, logistic regression, stepwise methods, ITT, winner country, clusters, Kmeans, PCA

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To God that once again, as always, illuminated my way during this journey.

"Os números dominam o mundo"
Platão

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ABBREVIATIONS

ESA- European Space Agency
EMITS- Electronic Mail Invitation to Tender System
ITT- Invitation to tender
BE- Belgium
CA- Canada
CH- Switzerland
DE- Germany
DK-Denmark
EE- Estonia
ES- Spain
FI- Finland
FR- France
GB- Great Britain
GR- Greece
IRL- Ireland
IT- Italy
LU- Luxembourg
LV- Latvia
NL- Netherlands
NO- Norway
PL- Poland
PT- Portugal
RO- Romania
RUS- Russia
SE- Sweden
US- United States of America
AUC – Area under a ROC curve
DTM- Document Term Matrix
AIC- Akaike Information Criterion
DF- Degrees of Freedom
AC- Agglomerative coefficient
OD- Odds Ratio
AGNES- Agglomerative Nesting
DIANA- Divisive Analysis
PCA- Principal Component Analysis

INTRODUCTION

Invitation to Tender (ITTs) are competitive processes that the European Space Agency (ESA) organizes to select contractors to develop certain research and development projects related to several space areas. It is largely through these ITTs, countries bring back the resources invested in ESA in terms of contracts.

This master project is the first step in the development of a study intending to use machine learning and statistical tools to find relation between words in Invitation to Tender (ITT) abstracts and the chance of certain country awarding a European Space Agency (ESA) ITT.

Using from simple to complex text mining techniques as, for example, searching for most frequent words in ESA Abstracts, this work looks to identify the relationship of certain words with the probability of a certain country winning a bid. Then, we will try to analyze the clustering of the documents in terms of words, to look for possible relations between the winning country and thematic areas.

Summarizing, this study looks to verify the hypothesis that words have relations with the chance of winning an ESA ITT, for some country. If this is confirmed, bidders' countries can optimize their strategies, saving resources, and increasing their probability to make good decisions, already before starting the proposal organization and proposal partners search.

This subject was developed because, while working in CENTRA-FCUL, in several occasions the proposal development was started but never submitted. Normally these proposals were from ESA and a few cases for the PT2020[1]. We gathered one year of proposals and organized them in two groups: started and submitted proposals and started and not submitted proposals. After dividing the proposals into these two groups, the author and her collaborators analyzed in detail the proposals and looked for reasons why they were not submitted. The main reasons were issues regarding partners or missing technical requirements.

A large amount of resources was lost searching for wrong partners and trying to fit CENTRA expertise in the ITTs. Considering this problem, we considered interesting to look for alternatives to improve CENTRA chance of winning ESA bids. And we hypothesized that we could improve partner selection by performing statistical analysis directly on the call texts.

[1] PT2020 – The Partnership Agreement between Portugal and the European Commission, labelled as 'Portugal 2020', acknowledges and underlines the role of R&I policy in promoting the country's competitiveness and internationalization.
https://rio.jrc.ec.europa.eu/en/library/portugal-2020-partnership-agreement

I – INITIAL ANALYSIS

1. Dataset compilation

The first challenge was to find available data, without problem with confidentiality, and in CENTRA expertise field. After a long time searching for a solution, the author remembered that ESA (our main client), provided information regarding ITTs status (e.g. awarded, re-issued, evaluated, canceled), in the dashboards monthly sent. Added to this fact, information regarding abstract, budget, responsibility, country, and others were publicly available at the EMITS (Electronic Mail Invitation to Tender System) website.
With the dataset defined, we started looking for all the correct information to guarantee the reliability of this study. We contacted the ESA Procurement Department, responsible for ESA Dashboards, and explained to them our study. They provided all the necessary information that is in public domain.
This work was developed using data from the monthly ESA dashboards.
We collected data from 2013 until 2016. The data used was based on three main sources, namely:

- 25 (twenty-five) tables from 2013- 2014;
- 17 (seventeen) tables from 2015;
- And 13 (thirteen) tables from 2016.

After organizing a file with all the awarded ITT, we were able to gather a dataset with 757 observations. With all these Awarded ITTs organized, a unique dataset, including all the information from EMITS web site, was constructed. The final table contains 17 (seventeen) columns, representing 17 variables, namely: *ESA Site, ESA reference number, Program Name, ITT Title, Program reference, budget, open date, closing date, countries allowed to participate in the ITT, price range, directorate name, department name, division name, responsible person, abstract, winner, country winner*.
All these variables are available in the dataset, but it does not mean that all of them were used in the present work. Only the relevant information for the hypothesis of this thesis were used, namely: *ITT abstract, ESA Office, Country winner and ESA Program*.
Before going on with the description of the study, some remarks about the data are relevant:

- The dataset has information regarding only the prime contractor for each ITT, although other countries could have some participation this information is not available (this proves to be challenging for Portugal, as it is usually only a partner in proposals from larger countries).
- All the ITTs awarded to the UK (United Kingdom) were registered as having the contractor GB (Great Britain).
- ESA has non-European participants in the ITTs, as it is the case of Canada (CA), United States of America (US) and Russia (RUS).
- A given ITT can appear in multiple monthly Dashboards. The information regarding ITT awards, was considered in the last version that it appeared. If some changes occurred between ESA dashboards revisions, these were not considered relevant.
- There are ITTs with more than one winner country, and that explains why the sum of Awarded ITTs is larger than the number of observations.
- ITTs that did not have any awarded winner where left outside this study.
- Missing information was completed as not applicable.

- In this dataset there are only 5 (five) different ESA Offices, although there are other offices, that do not make part of this study. Here, we considered public data from ITTs that were published and awarded. Each office has a different focus, which is as follows:
    1. ESA's headquarters (**HQ**)[2] are in Paris where policies and programmes are decided. ESA also has sites in other European countries, each of which has different responsibilities:
    2. **ESOC**[3], the European Space Operations Centre in Darmstadt, Germany;
    3. **ESRIN**[4], the ESA Centre for Earth Observation, in Frascati, near Rome, Italy;
    4. **ESTEC**[5], the European Space Research and Technology Centre, Noordwijk, in the Netherlands.
    5. **ECSAT**[6], the European Centre for Space Applications and Telecommunications, Harwell, Oxfordshire, United Kingdom.

1.1 Adopted software definition

Initial tables received from ESA where in Excel, but Excel lacks many statistical analysis features, besides slowing down significantly for larger data volumes. Thus we decided to adopted another environment more adapted to this study. The software chosen was R[7].
R is a free software environment for statistical computing and graphics, with many tools for text mining, statistics analysis, regression analysis, data analysis and many more other functionalities. There is a unified repository, where all new packages and releases are organized and available. This repository, CRAN[8], is the official source of all R packages and releases. Everything is accessible in the Internet so it can be easily spread and used around the world, besides encouraging scientific reproducibility. Since it has so many users, the software gets updated and more powerful every day. This software has a great feature which is that every programmer around the world can work in the development of R package tools. Also, there is a huge number of online forums. Users working together in the same tool make possible to discuss ideas and solutions while you are programming.
All the codes in this work were developed in R. This choice makes possible future uses and evolution of the developed tools and analysis, without extra resource expenses in infrastructure and licenses. Although we focused in ESA ITTs, this code can be used to get results regarding text mining and clustering for other types of tenders.

2. Initial dataset exploration

The original dataset format was in Excel. After the entire dataset compilation that we performed in Excel, we exclusively adopted R to further manipulate and analyze the data. Regarding our first challenge, it was necessary to use two R packages: XLConnect and Stringr. XLConnect is R

[2] HQ - https://www.esa.int/About_Us/Welcome_to_ESA/What_is_ESA
[3] ESOC – https://www.esa.int/About_Us/Welcome_to_ESA/What_is_ESA
[4] ESRIN – https://www.esa.int/About_Us/Welcome_to_ESA/What_is_ESA
[5] ESTEC – https://www.esa.int/About_Us/Welcome_to_ESA/What_is_ESA
[6] ECSAT - https://www.esa.int/About_Us/Welcome_to_ESA/What_is_ESA
[7] https://www.r-project.org/
[8] https://cran.r-project.org/

package for manipulating Microsoft Excel files from within R [1], and we used this package to be able to read the data within R. Stringr is an useful package for string and character manipulation, whitespace tools, locale sensitive operations and pattern matching operations [2], and it was used to perform the text manipulation on our dataset once it was in R.
To complete manipulate all the initial data and extract the information regarding the country from which the winner entity was, from the original dataset, we used one code also adopted by editors for text modification, the so-called regular expressions.
A regular expression, regex or regexp is a sequence of characters defining search pattern. Normally this pattern is used by string searching algorithms to "find" or "find and replace" operations on strings, or for input validation [3].
With the use of all packages listed above and regular expressions, it was possible to separate from the initial text, the information regarding the winner ITTs country. After this, the dataset was organized with all the information necessary to develop the proposed study. The final dataset had 17 columns. The original dataset included 16 variables and the 17th variable was created to register the winner countries.
One last procedure was necessary before starting building graphics: normalization of the dataset. In statistics, normalization means adjusting values measured on different scales to a common scale, often prior to averaging. In other words, using this procedure is possible to have the data in the same pattern. This guarantee that, the information is under the same assumptions and scale.
According to R.Hogg et al., "A very useful family of probability distributions is the normal distribution [4] which has shown to fit well to many observed variables in practice".
This happens, very often, because sums and averages of quantitites are approximately normally distributed as a consequence of the Central Limit Theorem and its generalizations.
The central limit theorem (CLT), implies that under most distributions, normal or non-normal, the sampling distribution of the sample mean will approach normality as the sample size increases [5].
In statistical analysis, it is often assumed that the population from which a sample was taken is normally distributed, symbolically, N (μ, σ^2) [6], where μ stands for the mean value of the population and σ^2 represents its variance.
In this case, the definition normalization is more related the necessity to organize the data in same pattern.
Using R, a matrix was created, where columns represent one country and lines one ESA Office:

		Countries																							
		AT	BE	CA	CH	CZ	DE	DK	EE	ES	FI	FR	GB	GR	IRL	IT	LU	LV	NL	NO	PL	PT	RO	RUS	SE	US
Offices	ESAT	1	1	0	3	0	1	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
	ESOC	1	0	0	3	0	20	2	0	11	0	6	6	0	0	6	0	0	0	1	3	0	8	0	1	0
	ESRIN	6	6	9	3	6	27	5	1	4	3	23	22	0	0	21	1	0	10	3	3	3	3	0	2	6
	ESTEC	16	40	2	20	4	112	5	0	40	19	80	90	12	3	70	0	1	23	7	6	14	4	0	18	1
	HQ	0	3	0	2	0	1	0	0	3	2	3	6	0	1	12	0	0	4	0	0	1	0	1	1	0

Table 1 – Matrix with ITT numbers distributed per countries and offices

This matrix represents the data used to create the reference for each represented relation in those graphics (except, graphic of ESA Programs)

Three graphics were plotted and for each one of then, data was organized using different references, as follow:

With data and the final dataset organized, it was possible to perform the first visual exploration by creating graphics that show the relations of the dataset columns. For such graphics, we use the following color encoding:

- Green color - no correlation between variables
- White color - correlations between variables is perfect.

The color scale starts at green color (no correlation) and finishes in white color (100% correlation). The lighter the color scale, the stronger the correlation between variables. The main objective of these graphics is to see the behavior of the relationships between ESA ITTs, Winner Countries and ESA Programs.

ITTs distribution considering normalization (reference) per countries:

We start by exploring the relation between the ESA centers and the countries winning ITTS.
The ratio por each relation is:

$$\frac{\text{ITT number per country in certain office}}{\text{ITT total number per country}}$$

From this, a visual representation of the matrix was created, considering winning Countries versus the ESA Office awarding the ITT. This is shown in Figure 1. As the proportion is performed per country, it is possible to verify how ESA Offices behave regarding the countries.
The information obtained here shows how ITTs distribute among countries considering each ESA Offices. It is possible to see that all countries have more ITTs awarded by ESTEC than by any other ESA office.
This happens because the total number of observations is larger in ESTEC than in other offices, and because ESTEC is a much more diverse center, awarding ITTs for different areas.

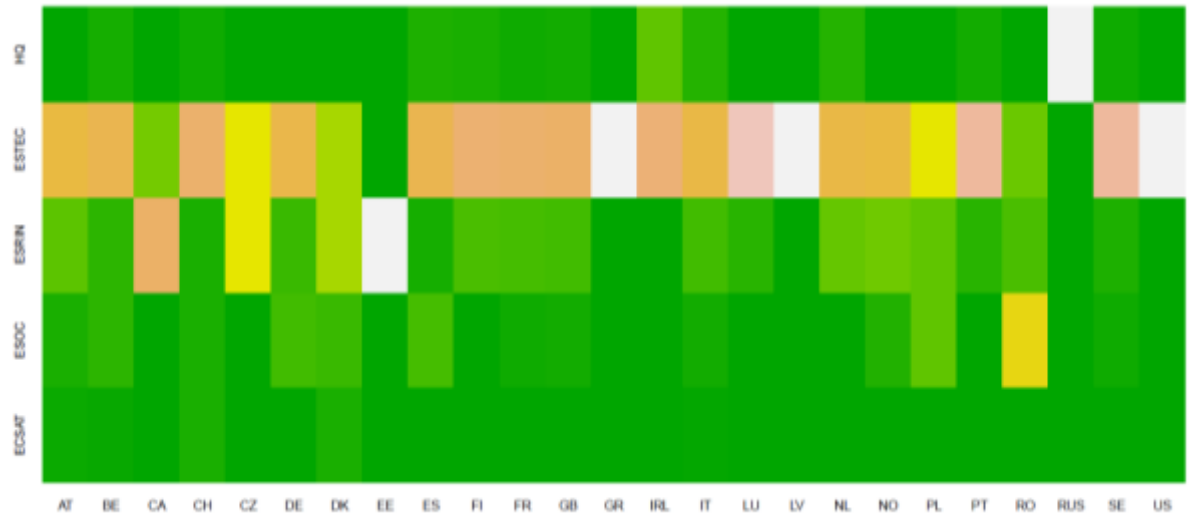

Figure 1- Countries X ESA_Office (normalization per countries)

However, there are further points to be raised from this matrix visualization:

- ESTEC is ESA's central Space Research and Technology Centre. Considering its broad research areas (everything that goes into a satellite), it is reasonable that this center has a huge number of ITTs awarded. Considering the ESTEC behavior towards different countries, it is expectable that they have business with almost all countries.

- Countries as GR (Greece), LV (Latvia) and US (United States of America), have a 100% awarded ITTs in ESTEC. It does not mean they did not submit ITTs in other offices, but they won just in ESTEC.
- ESRIN has a 100% correlation with Estonia (EE). That happened because Estonia has awarded ITTs only in ESRIN., indicating that they might favor Earth Observation.
- HQ has a 100% correlation with Russia (RUS). That happened because Russia has awarded ITTs only in HQ, indicating more sensitive negotiations
- ESOC does a lot of business with Romania (RO), comparing with other countries. We can consider Romania as an outlier in this case. Starting in 22 December 2011, Romania became the 19th Member State of the European Space Agency.
  The first agreement between Romania and the European Space Agency (ESA) was signed in 1992, followed in 1999 by the Romania-ESA Agreement on cooperation in the peaceful exploration and use of space. Starting in 2007, Romania contributed to the ESA budget as a European Cooperating State (PECS), status ratified by Law no. 1/2007[7].
  This summary shows that this outlier, in fact, has made efforts in space operation since a long time ago. Romania has her own organized Space Agency (ROSA- Romania Space Agency). Romania shows a great interest in Space Operations and probably developed good proposals for ESA. Regarding all the other offices, Romania awarded 14 ITTs during the period in study: 7 at ESOC, 3 at ESRIN and 4 at ESTEC. It is possible to confirm that Romania also has weaker correlations with ESRIN and a stronger correlation with ESTEC.
- All ESA Offices do business with Switzerland (CH). This can be justified because, Switzerland has a strong space office that supports Swiss bidders preparing the proposals, budget and partners search. The Swiss Space Center works closely together with the technology transfer office of ETH Zurich. The ETH technology transfer supports the ETH community in a broad range of intellectual property matters including the contractual negotiations with ESA that follow any submitted proposal/tender accepted by ESA [8].
- Czech Republic (CZ) has a good correlation with ESTEC and ESRIN.
- Poland (PL) has a good correlation with ESTEC, ESRIN and ESOC.
- Portugal (PT) has a small correlation with HQ and ESRIN and a little stronger correlation with ESTEC. Portugal has no awarded ITTs by ESOC and ECSAT (as prime contractor). Portugal has a very recent Space Agency, that until very recently was still under construction [9]. Other considerations that can be taken are:
  1. Portugal has no ITT awarded in the following areas: Space Applications and Telecommunications (ECSAT) and in Space Operations (ESOC). Probably, Portugal has not enough expertise or organized research & development in such areas.
  2. Portugal might lack a good network with the players of those areas and offices. Thus, a good opportunity for Portugal could be (after point 1 above is addressed) to contact Space Agencies and National delegations of other countries having high correlations with ESA Offices where Portugal has no business, namely, ECSAT and ESOC, looking to form partner clusters.
  3. One possible delegation to be contacted to reinforce relations could be Romania. Romania is a small country, relatively new in ESA and in the European Union [10]. The starting point might be to negotiate collaborations in ESOC, with whom the Romanians have a good correlation. This kind of deal could be fruitful for both countries and open new expertise areas in Portugal.

ITTs distribution considering normalization (reference) per ESA Offices:
The second relation we explored was considering the normalization per ESA Office.
The ratio por each relation is:

$$\frac{\text{ITT number per country in certain office}}{\text{ITT total number per office}}$$

The information shows ITTs distributions, considering the relation between the countries and ESA Offices. The question is: which office do the countries work with?
It is possible to see that most countries have a sparse relationship with the ESA Offices. Only Belgium, Germany and Italy have contracts in all ESA Offices. Probably, they have enough expertise in many areas that fits in ESA necessities.

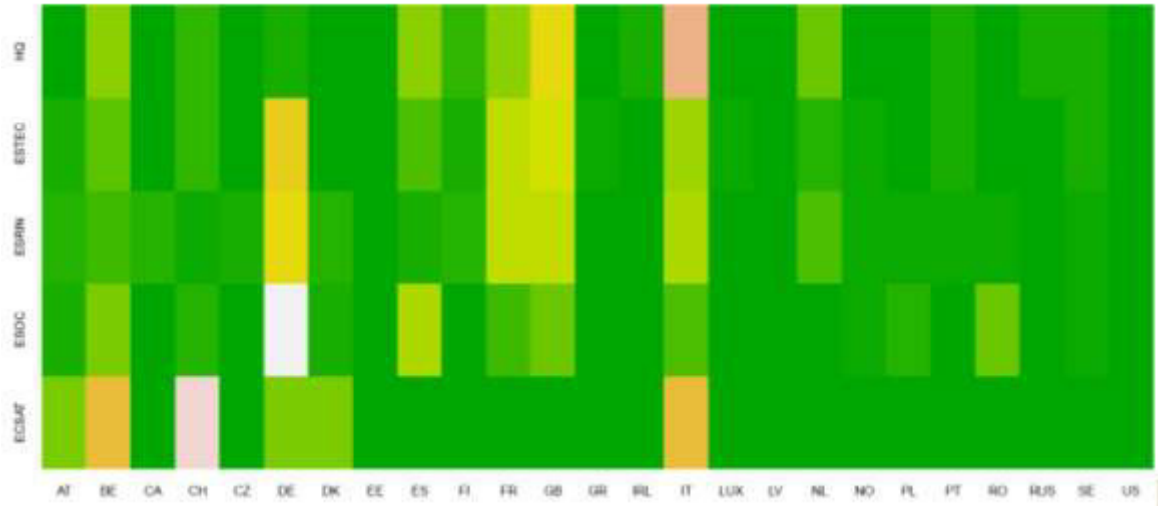

Figure 2- Countries x ESA_Office (normalization per ESA_Office)

- Belgium (BE) works with all offices. Belgium is the heart of many world organizations, e.g. NATO (North Atlantic Treaty Organization) [11]. Other relevant point is that ESA has an office in Brussels [12]. Considering this quick insight, we might say that Brussels is politically central to every important happening in ESA and in-Europe.
- Canada (CA) works with ESRIN, what makes sense since Earth Observation is one of Canadian major space focus areas. Canada has many satellites developed and under development with ESA for essential information on ocean, ice, land environment, and the atmosphere [13].
- Spain (ES) works with almost all ESA Offices. Considering that the Spanish have actions to include space knowledge since the elementary school, it is not strange to see the number of business they have with ESA. ESA has in Spain a European Space Education Resource Office (ESERO).
  "ESERO is an ESA education initiative providing qualified teacher training and dedicated curricular classroom resources and activities, using space to enable Spanish primary and secondary school teachers to inspire their pupils in STEM (Science, Technology, Engineering and Mathematics), trigger their natural interest and curiosity about the world

around them, stimulate the acquisition of scientific know-how and methodology, and help them develop the critical thinking they need to master their own future.
ESA's new ESERO office in Spain was formally inaugurated in Granada, October 2017. Hosted at Parque de las Ciencias, ESERO Spain joins the existing ESA ESERO network, which, for over a decade, has acted Europe-wide in support of national school education systems with innovative science teaching and learning strategies that use space as a context" [14].

- Germany (DE) works with all ESA Offices. Germany has its own space agency DLR-Deutsches Zentrum für Luft und Raumfahrt [15]. The major German efforts are in ESOC. This is natural once ESOC is in Darmstadt, Germany, however it might indicate location bias for contracts.
  Added to this fact, it is relevant to point out that DLR has 24 research institutes from many expertise fields, such as: Space Propulsion, Space Systems, Space Operations and Astronaut Training [16]. This huge number of research institutes suggests that Germany has a huge quantity of specialized researchers studying many different fields. Germany may bid in a lot of ESA ITTs from many different research branches. More proposals submitted also naturally results in more chance of winning at least a proposal.
- Italy (IT) works with all ESA Offices. The Italians have their own space agency. Considering this, they developed through the years expertise in many different areas in Space Sector, and with great chances to do business with ESA. Italians work together with ESA in many missions [17].
- Portugal has business with ESTEC, ESRIN and HQ. One possible reason for Portugal not to have awarded ITTs in other offices is: lack of expertise or even lack of partners. In this case, Portugal should improve its participation in other offices, contacting national delegations that do business with ESOC and ECSAT for productive collaborations. Good options could be Romania (as we identified in the previous section) or Poland. These countries normally fit in an ESA special programs under geo returns. This Industrial Policy and Geographical Distribution play an important role in ESA procurements. One of the main elements, in ESA's Industrial Policy, is the set of rules relating to geographical distribution or fair return [18].
  Another possibility is that Portugal should contact delegations of countries as Germany, Italy and Switzerland. Those countries have business with all ESA offices, and possibly expertise that is missing in Portugal, and those are necessary to improve Portuguese Space Sector and relevance in an ESA context.
- Switzerland has business with all ESA Offices, except ESRIN. This is expectable, once Switzerland has big companies for Space sector, as Ruag Space.[19]
- France (FR) and Great Britain (GB) do business with 4 ESA Offices (ESOC, ESTEC, ESRIN and HQ). These countries have a good relationship with those offices. France has her own Space Agency CNES [20] that is the largest budget contributors to ESA, besides being a major partner in launch services from Arianespace, as it is also the case of Great Britain [21].

An additional study was done to verify if the countries with more awarded ITTs had more institutions and investment dedicated to space field, e.g., space office with dedicated professional staff or a complete space agency.

Considering all the points raised regarding the two plotted graphics, one hypothesis was raised: is there any relation between the number of ITTs awarded and the number of employees dedicated to space sector?

To answer to this question a research comprising extensive search in the Internet and contacts with Space Agencies and National Space Offices was done. Information regarding space agencies and space offices in Europe and Canada was collected. All data we found in the internet and that were provided by space agencies and space offices is organized in Table 1.

This table summarizes all the information that was sent by agencies and space offices around Europe and Canada.

As shown, many countries did not answer the question about the number of employees, but countries with more awarded ITTs sent the information (except GB and BE). The country with more employees is Germany with 8.127. Italy has 237 employees. France in 2017, hired 98 new employees. All documents related to these numbers are attached in final part of this study.

Considering the number of employees, it is easy to conclude that Germany wins more, but also has more employees directly paid by space-oriented budget in the Space Area.

Poland does not have a lot of participation in ESA but considering that they just exchanged Accession Agreements to ESA in September 2012 and already have a space agency with 48 employees, we can expect Poland to have a relevant participation in ESA ITTs.

Spain is not among the 5 players chosen for this study. They have 1200 employees dedicated to space sector technical issues. Regarding their efforts, we can expect Spain in a continuous growing number of ITT awarded.

Italy has less employees than Spain, but more awarded ITTs. This is in direct relation to the investment from Italy in ESA, that is the third major contributor to ESA budget, with more than two times the investment from Spain.

Space Office	Space Agency	Country	Final action status	Answered?
	x	Romania	Email sent 14/10/18	No
x		Belgium	www@belspo.be	No
x		Switzerland	Form sent by internet 14/10/18	No
	x	Canada	14-10-2018 - by form internet	YES- 670 employees (answered 24-10-18)
	x	Germany	14-10-2018 - by form internet . Another form sent 26/10/18 (https://www.dlr.de/rd/desktopdefault.aspx/tabid-2096/). Form answered in 26/10/2018)	Yes -here are the figures (as of September 2017): Total number of employees: 8.127 (2.587 female) Non-scientific staf f: 3.404 (50.7 % female) Scientific staff: 4.723 (18.2 % female) Average age: 40 years PhD candidates: 969 Trainees: 237 Student interns: 440
	x	Italy	14-10-2018 (urp@asi.it)	YES - 16-10-2018 (237 employees)
	x	France	14-10-2018 - by form internet	YES- 23/10/18 (report annual in french)
x		UK	14-10-2018 - info@ukspaceagency.gov.uk	No
	x	ES	14-10-2018 - relaciones.institucionales@inta.es	YES-26/10/18 - Around 2000 employees, 1200 of them dedicated to direct scientific- technical activities
	x	PL	14-10-2018 - sekretariat@polsa.gov.pl	Answer received 17/10/18 - 48 employees
x		PT	14-10-2018 -facc@fct.pt.	No
x		AT	15- 10-2018 - Michaela Gitsch michaela.gitsch@ffg.at	Yes - 13 employees
x		CZ	15- 10-2018 -info@czechspace.cz	No
x		DK	15- 10-2018 -office@space.dtu.dk	YES - 17/10/2018 (150 employees)
x		EE	15- 10-2018 - info@eas.ee	YES - 15-10-2018 (2 employees)
x		FI	15- 10-2018 - kimmo.kanto@ businessfinland.fi	No
	x	GR	15- 10-2018 - internet form	No
x		IRL	15- 10-2018 -www.space-ireland.ie	No space agency - but 5 persons working to space
x		LUX	15/10/2018 - info@space-agency.lu	No
x		LV	15/10/2018 - info@vatp.lv	No
	x	NO	15/10/2018 - spacecentre@spacecentre.no	No

Table 2- Space sector in Europe and Canada

ITTs normalization (reference) per ESA_Programs

Using the same dataset (with only the information regarding the ITTs awarded), it was possible to make another analysis considering how the ESA Programs were distributed per countries.
ESA Programs are a way that ESA "solves issues". Normally, ESA creates a program that will have a lot of associated projects for solving a bigger issue.
In this case, the normalization was made considering the total number of ITTs divided per Programs name per country. The ratio por each relation is:

$$\frac{\text{ITT number per country in certain program}}{\text{ITT total number per program}}$$

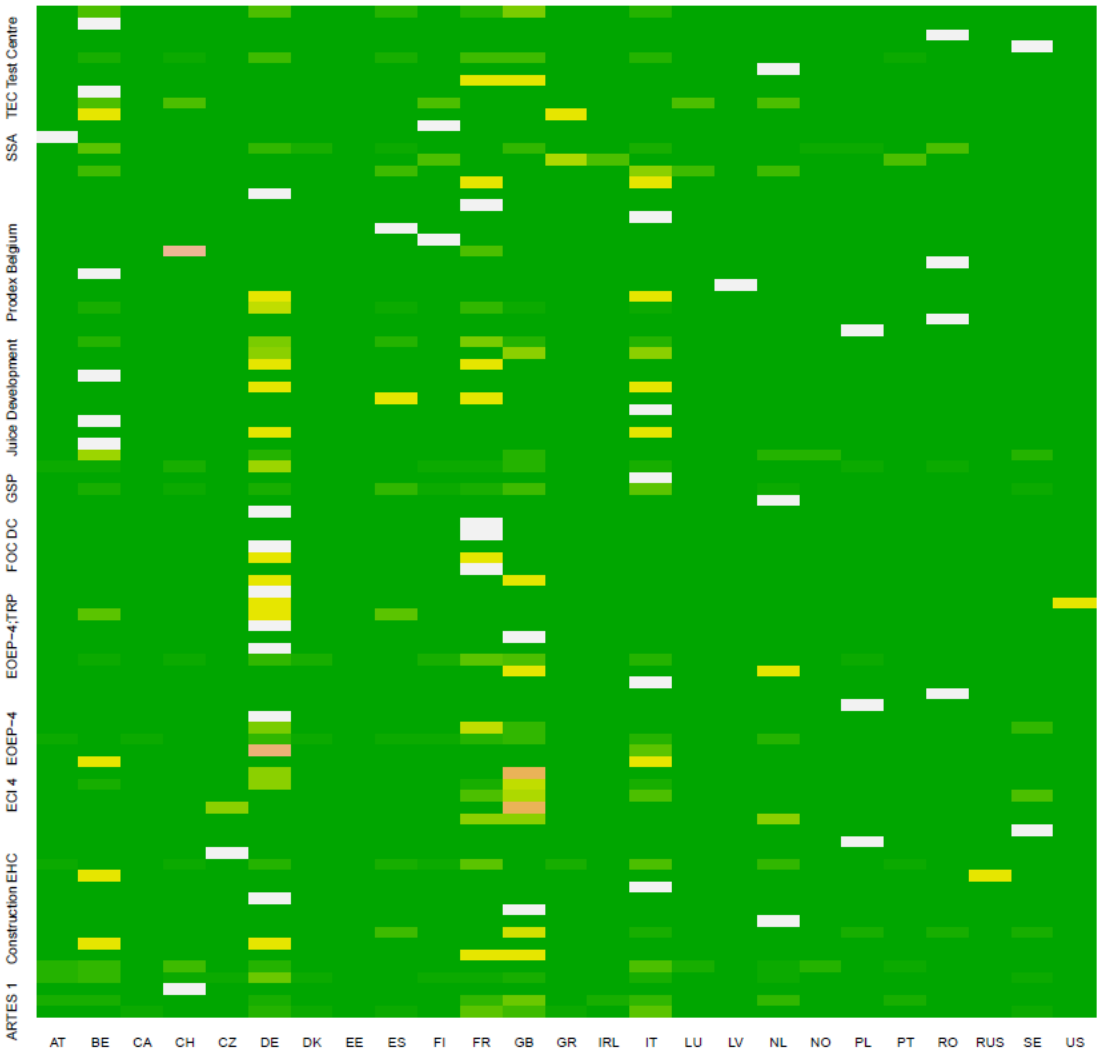

Figure 3- Coutries x ESA programme

- It confirmed that countries having a good correlation with almost all ESA Offices (Germany, Italy, France, Great Britain), have a NEGATIVE correlation with each other. In other words, for example, in ESA programmes that Germany wins, the other 3 major countries (Great Britain, France and Italy) have almost no ITT awarded.
  When one big player wins, another big player is out, and they complete each other. If it was possible to compile all those ITTs considering them as just a single country they would be in almost every ESA program.
- Portugal (PT) has a small participation as prime for ESA Programs. It is possible to say that Portugal has an irrelevant participation in ESA programs when we consider all ESA Members. Portugal awarded 17 ITTs as prime contractor in 757 observations. This is also expected given the very small investment from Portugal in ESA (0.4% of the annual budget for 2019). Small countries as Romania, Czech Republic and Poland have stronger correlations than Portugal with a given ESA program.
- Belgium (BE) could be called the fifth country in awarded ITTs. Belgium has a negative correlation with the big four countries. It means that Belgium works in Programs that

Germany, Italy, France, Great Britain normally do not have a lot of participation, almost as if it was avoiding the major countries

If we could put together the 5 countries Germany, France, Great Britain, Italy and Belgium, as one, it would be winning around 76% of the ESA ITTs (575 of 757 observations).

- In the graphic it is possible to verify a lot of white cells indicating a perfect correlation between the country and ESA Program. This is not difficult to happen. There are many programs dedicated to specific countries which do not allow the participation of other countries. ESA can create one ITT considering special needs and interests from a certain country. In the database, it is possible to find special dedicated programs to Romania (RO), Poland (PL) and Czech Republic (CZ).

Comparison of the three graphics analyzed above:

In the first graphic it was possible to analyze how ESA Offices behaves with countries (who/how ESA Offices contract). In the second, it was examined how countries distribute their efforts among ESA Offices. In the third and last graphic, it was possible to identify how the ESA programs are distributed among countries.
Considering all the relevant points observed, it might suggest that:

- Countries with well-defined interests, normally represented by a local Space Agency, have more ITTs awarded, capillarity among ESA Offices and more flexibility to work with different ESA programs.
- Small countries with a Space Agency can have an important participation in focused ESA ITTs (e.g. Romania)
- Countries with no Space Program defined by a Space Agency or Space Office become less important as prime contractors.
- Regarding the huge concentration of ITTs in 5 countries, Belgium, Germany, France, Italy and Great Britain, it is possible to say that other countries work only with the ITTs that were not relevant for countries with a defined space strategy and good know-how in specific areas.
- Small countries such as Ireland, Portugal, Poland and Romania have sparse correlation with all the ESA Offices, except ECSAT. This fact could suggest that those countries could cluster together and join forces to have more participation in ESA ITTs.
- Using the information provided by these three graphics, every country involved in this study can at least “see clearly” what are their strengths and how they should improve their efforts to win more ESA ITT.

These firsts results were possible using the relations between the number of ITTs per countries, offices, and programs.
From now, another type of study will be developed: text analysis relating words in ITT abstract with the chance of certain country wins an ESA ITT.
Text mining techniques will be used to “clean” the dataset from “useless” information and prepare it for the models and cluster analysis.
This next part will be developed considering only the five countries with more awarded ITTs in this dataset. For them, models and analysis will be made.

3. Text mining

One of the major focus of this thesis was the capacity to work with text.
According to Ronen Feldman & James Sanger, "Text mining is a technique that tries to solve issues regarding overload information using, data mining techniques natural language processing (NLP)[9], information retrieval (IR), and knowledge management.
According Ronen Feldman & James Sanger, "Text mining uses document collections pre-processing (text categorization, information and term extraction), intermediate representations storage, and analysis, and results visualization". [22]
Normally, relevant information is hidden inside a huge number of paragraphs and words that requires the correct preparation to reveal this information. This is what usually is called unstructured data. This analysis task becomes more complex when there is a huge number of documents to be analyzed.
According to Tandel et al., [2019] "Text mining examines in detail text in natural language and then lexical patterns are detected to extract important information".
The usual necessary steps to organize unstructured and messy data are presented in figure 4 [24].

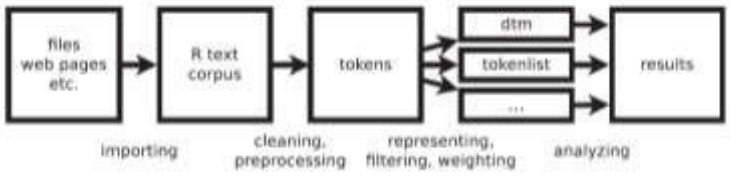

Figure 4- Suggested data mining flow

There are different ways to store text in text mining approaches. Until now, our database was manipulated using R tools for string and character extraction. Here text will be manipulated in a way that makes possible to clearly quantify the information hidden inside the characters and strings.
Text is usually stored as strings (i.e., character vectors) within R, and often text data is first read into memory in this form. But another way, better to perform analysis, is a Corpus.
"A Corpus is a type of object that contains raw strings annotated with additional metadata and details ".[25]
There are special packages in R for text manipulation. In this study we mostly used the TM package.
The text information basis of this study is the Abstract column from ESA ITTs. Tools were used for the following tasks:

- StemDocument - to maintain the main word root;
- Tolower - to convert the text in lower case. "R" is Case sensitive, and it is completely mandatory to put all the text in lower case to avoid the same word recognized twice, one in lowercase and other with uppercase;
- Stopword - to remove meaningless words like, a, an, the.
- RemoveWords - to remove selected words. In this case, words that appeared more than 300 times were removed from the database. Words that are ordinary, with many repetitions do not contain relevant information.
- StripWhitespace - to remove extra white spaces.

[9] Natural language processing (NLP) is a subfield of computer science, information engineering, and artificial intelligence concerned with the interactions between computers and human (natural) languages,

- RemoveNumbers - to remove numbers from the text.
- WordStem - This function extracts the stems of each of the given words in the vector.

After these steps, the dataset is ready to become a Corpus to generate a document term matrix (DTM). According to K. Welbers et al., "Document term matrix (DTM) is one of the most common formats for representing a text corpus (i.e. a collection of texts) in a bag-of-words format".
The DTM is a matrix where rows are documents and columns are the variables (in this case, the most frequent words). Each cell indicates the frequency each term or variable appears in the document. Using this representation is easier to analyze vector and matrix, as number, not text.
Added to this, DTM format is more memory efficient and allows the analysis with optimized operations. Two of the most established text analysis packages in R that provide dedicated DTM classes are TM and Quanteda".[26]
After applying the afore mentioned tools (StemDocument, Tolower, Stopword, RemoveWords, StripWhitespace, RemoveNumbers and WordStem) to all dataset, we selected the most frequent words, those that appeared more than 300 times in the dataset, in a first step.
Those words are:
"activ","also", "base", "can", "current", "develop","esa", "high", "includ","level", "new", "oper" , "perform", "process", "provid", "requir", "satellit", "servic","shall", "space", "support" "system", "technolog", "use" , "data", "design", "implement", "stud", "test", "mission", "procur", "model", "need" ,"object", "addit","inform","measur","smes","will", "phase"

A second step was performed to remove those words from our documents and define the final DTM. The data is then ready to have the sparsest terms removed, and words that appears in 85% of the documents kept. Finally, we found our relevant terms (words). We have 60 words with maximum length of 10 characters, and the data characteristics are:

```
<<TermDocumentMatrix (terms: 60, documents: 757)>>
Non-/sparse entries: 9497/35923
Sparsity          : 79%
Maximal term length: 10
Weighting         : term frequency (tf)
```

The definition of the word's frequency cut point has a relevant role in DTM definition. For example, the same procedure for a new DTM was done. First, the code for "Most Frequent Word" was compiled for words with frequency of 250 times. The number of words increased from 40 words to 50 words, namely,

"activ","also","applic","base","can","current","develop","differ","esa","ground","high","includ","level","new","oper","perform","process","propos","provid","requir","satellit", "servic", "shall",
"space","support","system","technolog","use","data","design","implement","power","product", "studi","test","futur","mission","procur","entiti","model","need","object","programm","addit", "inform","measur","pleas","smes","will","phase".

In this example, the final DTM has a smaller number of terms:

```
<<TermDocumentMatrix (terms: 51, documents: 757)>>
Non-/sparse entries: 7824/30783
Sparsity          : 80%
Maximal term length: 10
```

Weighting : term frequency (tf)

This other simulation was done to demonstrate that the parameter defined by the user can impact the models. In this study, our final selection was to remove words that appeared 300 times.
One possible way to find relationships between variables is using a correlation matrix, that can be easily visualized in R using the corrplot package.
According to David Shen & Zazai Lu, in 2006 a correlation is a measure of the strength of linear relationship between random variables. The population correlation between two variables X and Y is defined as

$$\rho\,(X, Y) = \frac{\operatorname{cov}(X,Y)}{\sqrt{\operatorname{Var}(X)\operatorname{Var}(Y)}}$$

The parameter ρ is called the product moment correlation coefficient or simply the correlation coefficient.
This number summarizes the linear relation, considering the direction and closeness between two variables. The sample value is called r, and the population value is called ρ (rho). The correlation coefficient can take values from -1 to +1. The sign (+ or -) of the correlation defines the direction of the relationship. When the correlation is positive ($r > 0$), it means that as the value of one variable increases, so does the other.[27]
We created such a matrix to reveal how the 60 most frequent words are related. This is represented in Figure 5. When the color becomes darker and the points are becoming bigger a stronger relation exists between the variables that are in coordinate X x Y. Using this tool, it is easy to identify words that appear together.

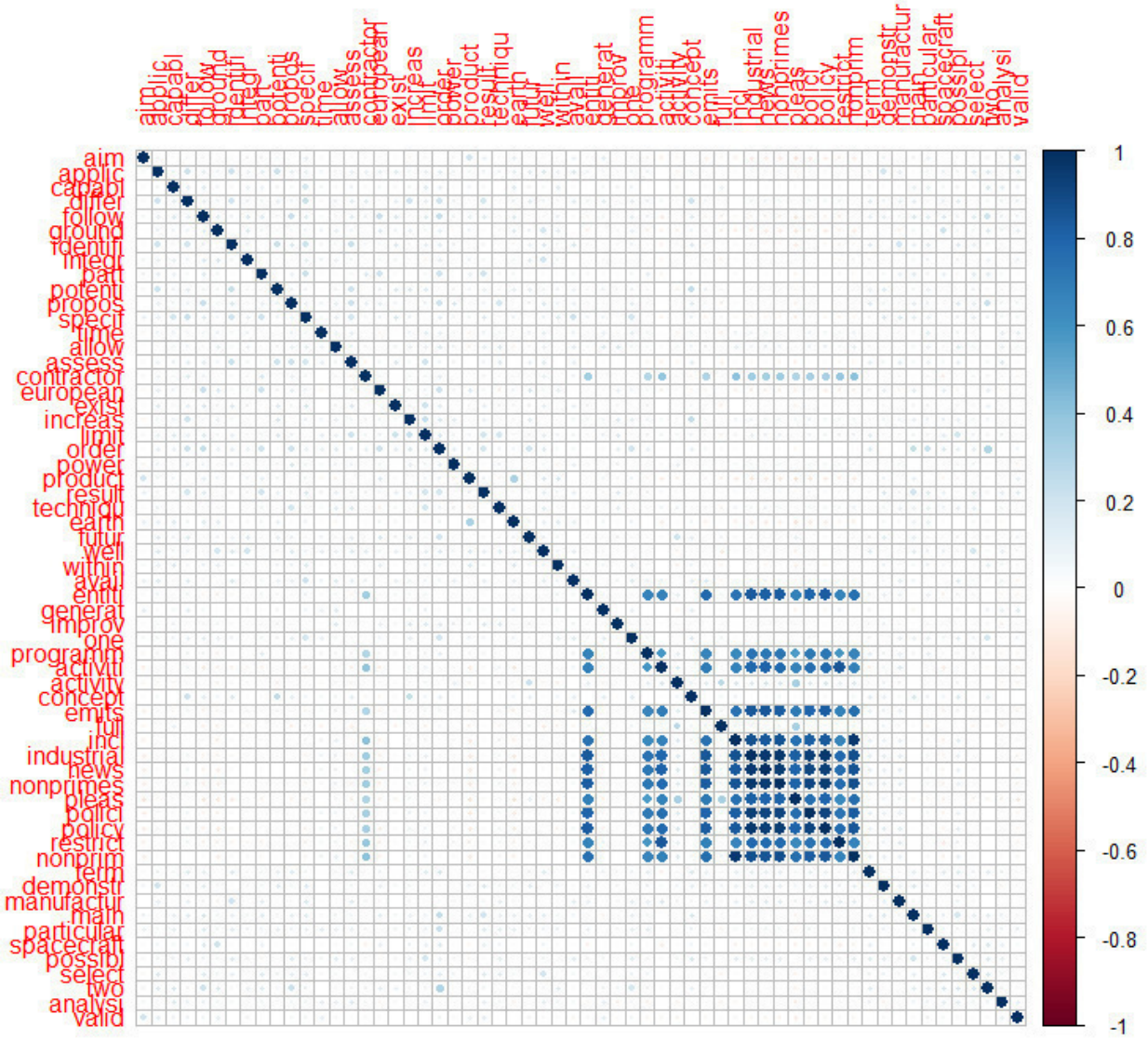

Figure 5- Correlation Matrix of the 60 most frequent words in the DTM extracted from the ESA ITTs.

Finally, in Table 3, the most relevant relations appearing in the correlation matrix are represented. Again, the scale of blue, from light to dark, was used to define how strong is the relation.

Table 3- Correlation matrix - most important relations

	contractor	entiti	program	activit	emits	full	incl	industrial	news	nonprimes	pleas	activity	polici	policy	restrict	nonprim
contractor																
entiti																
program																
activit																
emits																
incl																
industrial																
news																
nonprimes																
pleas																
polici																
restrict																
noprim																

II - REGRESSION MODELS

1. Overview

One of the firsts visual exploration of the database we constructed in this study showed the distribution of ESA ITTs awarded in a Countries versus ESA Programs matrix (Figure 3).
It was possible to conclude from this analysis that 5 (five) countries had more ESA Programs participation than others. These five countries are: Belgium (BE), France (FR), Germany (DE), Great Britain (GB) and Italy (IT). They together appeared 575 times in 757 ITTs observed. Considering this, without any further information, it is possible to infer that when ESA announces one ITT one of these countries have a possibility of winning around 575/757 (76%) as prime contractors. To study if it would be possible to predict the chance of each one of these countries to win an ITT based on the words written in the ITT abstract, we study then the development of statistical models using the 60 variables selected in the previous chapter as parameters.

2. Regression model and variables selection methods

In this work we explored Logistic Regression models and variables selection methods, as Stepwise Forward, Stepwise backward and Stepwise both (hybrid).
In the first chapter were defined the variables to be used in the models: 60 words that appear in 85% of the documents and have some relation between each other, as confirmed by the Correlation Matrix (Figure 5). Most relevant relations were represented in Table 3. Now, we focus in searching to build models that relate abstract words with the chance of certain country winning an ITT.
For example, the logistic regression is done between the most frequent terms and the frequency of them in each abstract from awarded ITT. The most frequent terms were observed if appeared or not in the awarded ITT. Terms were identified to a coefficient and included in a model.
In the end, the models will answer the principal point of this study: Which words should be in the ITT abstract to indicate that a certain country has more chance of winning?
The models will relate language terms that guarantee that the chance of success is not random[10], and the fact that they appear in an ITT, increase the chance of success of a certain country in the ESA tender.
We developed an individual model for each. As there are 5 countries and 4 models per country, 20 models were developed.
Before discussing the development of the models, it is necessary to understand the basic concepts of regression.
According to R. Hogg *et al. [2015],* "Regression is a technique that explains the result of some process in terms of some associated (explanatory) variables by means of a mathematical model". Models are created to estimate variable response , when explanatory variable values are know If , there is an idea to create an equation that relate these variables, it is possible to say that we can "fit" the model to the data[28] and try to guess the future, or predict the response. There are several types of regression but the one that will be used in this work is Logistic Regression.

[10] Random chance is: 50% chance of success and 50% chance of loss. For every hypothesis, the chance is always 50/50. When it´s not aleatory, this ratio varies, and the chance of success is more than 50% and consequently the chance of failure is smaller.

Logistic regression analyzes the relationship between multiple independent variables and a categorical dependent variable and estimates the probability of occurrence of an event by fitting data frequencies to a sigmoid function called logistic curve.
There are two models of logistic regression, binary and multinomial logistic regression. Binary logistic regression is used when the dependent variable is dichotomous, and the independent variables are either continuous or categorical. In this case the answer can have two status: right or wrong, yes or no, usually measured by "1" and "0". In this study only the binary option will be analyzed.
In logistic regression, the probability of the response variable, say *Y*, taking the value 1 when the explanatory variables take the values x_1, x_2...,x_k is given by:

$$P\{Y=1|\, x_1, x_2,...,x_k\} = p(x_1, x_2,...,x_k) = \frac{e^{b_0+b_1x_1+...+b_kx_k}}{1+e^{b_0+b_1x_1+...+b_kx_k}} \quad (1)$$

where b_0, b_1, b_k are coefficients to be estimated from the data. They are estimated using the maximum likelihood method, that is, they take the values that maximize the probability of the observed sample.

For a sample of size *n* of the response variable, (y_1,y_2,...,y_n) and considering (x_{i1}, x_{i2},...,x_{ik}) the corresponding values for the explanatory or independent variables, *i*=1,...,*n*, and supposing that the observations follow a logistic regression model, the likelihood function is given by:

$$L(y_1, y_2,..., y_n; b_0, b_1,..., b_k) = \prod_{i=1}^{n} p_i^{y_i}(1 \quad p_i)^{1 \quad y_i} \quad (2)$$

where $p_i = p\,(x_{i1}, x_{i2},...,x_{ik})$. Consequently, its logarithm, usually called the loglikelihood function, turns out to be:

$$\ln L = \sum_{i=1}^{n} y_i \ln p_i + (1 \quad y_i)\ln(1 \quad p_i). \quad (3)$$

To maximize the loglikelihood or, equivalently, the likelihood, we have to obtain the derivatives of this function in order to each coefficient b_j, *j*=1,...,*k*. Setting this derivatives equal to zero we get a set of equations that is usually called the normal equations. In this case the normal equations are given by:

$$\sum_{i=1}^{n} x_{ij}(y_i \quad p_i) = 0,\ j=1,...,k, \quad (4)$$

where the p_i's are a function of the coefficients as in formula (1). The roots of these system of equations are the maximum likelihood estimators of the coefficients, denoted by $\hat{b}_j$, j=1,...,k. However, as the system has not analytic solutions an iterative method like, for example, the Newton-Raphson method, must be used.

The likelihood function calculated in the estimates of the coefficients, $L = L(\hat{b}_0, \hat{b}_1, ..., \hat{b}_k)$ gives an estimate of the probability of the sample and, if the model has a good fit, should be relatively large.

According Peter Bruce & Andrew Bruce in Practical Statistics for Data Scientists, "Linear regression is fit using least squares, and the quality of the fit is evaluated using RMSE and Rsquared statistics" In logistic regression there is no closed-form solution and the model must be fit using maximum likelihood estimation (MLE).

Maximum likelihood estimation is a method that tries to find the most similar result that can be produced by the data. Logistic regression is flexible, because using variables that are transformations of the original variables, or adding such variables to the model, allows a great variety of curves. However, logistic regression may produce poor estimates for the coefficients when the set of explanatory variables has a problem of multicollinearity.

According to A. Bager et al., [2017] in "Addressing multicollinearity in regression models: a ridge regression application", the multicollinearity problem is defined as the association between two or more explanatory variables through a strong linear relationship in which the effect of the dependent variables cannot be separated from that of the explanatory variables "[29]. Variables strongly correlated produces multicollinearity, in this case, there is redundancy among the predictor variables.

Perfect multicollinearity occurs when one predictor variable can be expressed as a linear combination of others. Multicollinearity may occur when:

- A variable is included multiple times by error;
- Two variables are nearly perfectly correlated with one another.;
- One variable is approximately a linear combination of others.

According Peter Bruce & Andrew Bruce, "Multicollinearity in regression must be addressed. Variables should be removed until the multicollinearity is not present. A regression model has not a well-defined solution in the presence of perfect multicollinearity". [30]

Summarizing, multicollinearity occurs when two or more variables contain the same information about the model and, in this way, it is necessary to keep only the most relevant.

In final Attachment, will be possible to find all the logistic models adjusted to the 5(five) countries, where the response variable is 1 if the country was awarded a certain ITT or 0 otherwise and the independent variables count the number of times a certain word was included in that ITT abstract. Stepwise selection methods were used to select independent variables, namely, forward, backward and both (hybrid). These variable selection methods avoid including all the variables in the model, producing a simpler and more parsimonious model, and helping to avoid multicollinearity problems.

As described by G. James *et al*.,2015 in An Introduction to Statistical Learning with Applications in R book, "Forward stepwise selection starts with the intercept, and then sequentially adds into the model the predictor that most improves the fit".

Stepwise forward method starts with no variable in the model, only the intercept. Then, step by step, the most significant variable is included. Interactions are done, while significant variables are found. If the variable is significant, it means the test on the variable coefficient indicates this it is not null, it is included, otherwise, the procedure stops with the present variables.

In backward stepwise, the model starts with all variables. An interaction will be done in the full model, to remove the less significant variable. This procedure will be done, until the moment all variables are significant.

Hybrid version or Both direction version, it is known as a stepwise where forward and backward method are available. In this method, the variable can be included in the model, and another

interaction can be done and after adding this variable, another one can be removed from the model, to improve it. After that, it is possible, that the model removes another variable that no longer contributes with the model improvement. [31]
In both directions' stepwise method, the variables are added and can be removed if the variable does not bring important information to the model. To define which stepwise is the best, one option it to use AIC "Akaike information criterion".
In the R package, the step function uses the AIC criterion for weighing the choices, which takes proper account of the number of parameters fit; at each step an add or drop will be performed that minimizes the AIC score.[32]
The Akaike information criteria (AIC) is based on the symmetric of the loglikelihood of the sample and, thus, the larger the loglikelihood, that is, the better the model fits to the data, the smaller is the AIC. However, the AIC information criteria takes into consideration the number of parameters in the model, once many parameters introduce more sources of error and, sometimes, multicollinearity in the model. For this reason, the AIC is given by:

$$-2\ln L\ -2(k+1),$$

where k is the number of explanatory variables and $(k+1)$ is, thus, the number of parameters in the model.
The model choice considers the option with smaller AIC number and less associated variables in the model. Big AIC numbers indicate many parameters to be fitted; small AIC numbers indicate fewer adjustments. Models with a huge number of variables normally are not selected, because it could represent many degrees of freedom[11] to deal.
In final attachments, we add the developed logistic models, and them used stepwise methods to better select the model's variables, for all the 5 countries with more awarded ITT.

3. Models comparison and choice

After the development of these 3 stepwise methods, we compared their Akaike Information Criterion (AIC) and the number of Degrees of Freedom (DF). In what follows mstep represents the stepwise model, mstepb stands for stepwise both and stepbw for stepwise backwards.

Germany:
After the development of these 3 options, their AIC was compared in order to choose the best one. In what follows mstep represents the stepwise model, mstepb stands for stepwise both and stepbw for stepwise backwards.

```
> AIC(mstep_DE,mstepb_DE,mstepbw_DE)
             df      AIC
mstep_DE      9 733.8035
mstepb_DE     9 733.8035
mstepbw_DE   12 732.1902
```

Considering these two parameters, the best choice could be "Stepwise Both or Stepwise Forward", because they have the smallest number of degrees of freedom with a similar value for the AIC.

[11] Degree of freedom is the number of values in the final calculation of a statistic that are free to vary. https://en.wikipedia.org/wiki/Degrees_of_freedom_(statistics) [Accessed in April 7,2019].

The AIC number moderately larger than in the backward stepwise but considering that this option has 3 degrees of freedom more, the choice could be stepwise forward or both.
The backward option should not be chosen, because it has more than 3 degrees of freedom than the other two. One important concept is that there is no "wrong model", there are models that fit better than others, and models that reveal more real, physical, information than others, or models that reveal no information at all, as a worst case.

Belgium:
After selection variables for the model using the three stepwise methods, the corresponding AIC and degrees of freedom were compared. The results were as follows.

```
> AIC(mstep_BE,mstepb_BE,mstepbw_BE
           df      AIC
mstep_BE   11 464.5180
mstepb_BE  10 464.2837
mstepbw_BE 10 464.2837
```

It is possible to see that the AIC number is practically the same for any Stepwise Method as the number of degrees of freedom differs in one unity. It is possible to do any choice in this case; differences are not expected to be relevant between the three possibilities.

France:
The procedure to compare the selection variables methods was repeated for France and the results were as follows.

```
> AIC(mstep_FR,mstepb_FR,mstepbw_FR)
           df      AIC
mstep_FR   16 614.1712
mstepb_FR  16 614.1712
mstepbw_FR 19 610.2985
```

The best choice between the 3 developed models can be Stepwise both or forward, because they present the same degree of freedom and AIC number. The stepwise backward even though having the smallest AIC number, has 3 (three) degrees of freedom more than the other options. So, more degrees of freedom, more parameters that can vary, more possibility of error.

Italy:
After the development of the 3 stepwise options, both the AIC and the number of degrees of freedom were compared.

```
> AIC(mstep_IT,mstepb_IT,mstepbw_IT)
            df      AIC
mstep_IT    17 584.3204
mstepb_IT   17 584.3204
mstepbw_IT  17 585.0713
```

Following the same criteria to select the best option, this could be Stepwise both or forward, because they present the same number of degrees of freedom and AIC value.

Therefore, there is practically no difference between these three stepwise methods, because the AIC number difference is less than 1(one) unit. In this case, any model could suit.

Great Britain (GB)

After the development of these 3 options, the correspondent AICs were compared.

```
> AIC(mstep_GB,mstepb_GB,mstepbw_GB)
             df     AIC
mstep_GB     10 647.0014
mstepb_GB    10 647.0014
mstepbw_GB   13 644.1195
```

The best choice between the 3 developed options can be Stepwise both or forward, because they present the same degree of freedom and AIC number. The stepwise backward even though having the smallest AIC number, has 3 (three) degrees of freedom more than the other fitted models.

Unfortunately, Portugal was not chosen for the development of regression models. In the dataset considered in this study, Portugal has only 17 observations, and that is a very small number to be representative and conclusive.
After the models were constructed predictions can be done, so that the results of ITT winners from the data set and the values predicted by the models will be compared.

III - FITTED VALUES, PREDICTION, ROC CURVE AND ODDS RATIO

After the development of all models, comparison with option of stepwise methods were done. It was indicated the best options and explanations were raised for the countries. From now, it is time to start prediction. It was chosen as best regression model, the option using Stepwise forward, as variable selection method.
Here are shown all final 5 regression models for each country, presenting the variables that are in the final selected model:

Stepwise forward - Germany				
Variables	Estimate Std	Error	Z value	Pr(>|Z|)
(Intercept)	-1.55850	0.13373	-11.654	< 2e-16 ***
concept	0.29128	0.09564	3.046	0.00232 **
limit	-0.73729	0.26724	-2.759	0.00580 **
order	0.33995	0.13300	2.556	0.01059 *
futur	-0.32878	0.15429	-2.131	0.03309 *
ground	0.22004	0.09746	2.258	0.02395 *
full	0.38207	0.17421	2.193	0.02829 *
product	0.16883	0.08160	2.069	0.03855 *
generat	-0.27864	0.20318	-1.371	0.17026

Table 4 – Stepwise forward – Germany

Stepwise forward - Belgium				
Variables	Estimate Std	Error	Z value	Pr(>|Z|)
(Intercept)	-2.0726	0.1897	-10.928	<2e-16 ***
limit	-0.6203	0.4064	-1.526	0.1269
assess	-0.4415	0.2796	-1.579	0.1144
aim	0.2928	0.1568	1.868	0.0618 .
generat	-0.3740	0.3090	-1.210	0.2261
capabl	0.3356	0.1802	1.862	0.0626 .
improv	-0.4234	0.2831	-1.495	0.1348
analysi	-0.4521	0.2840	-1.592	0.1114
contractor	0.2848	0.1377	2.068	0.0386 *
incl	-1.1482	0.4843	-2.371	0.0178 *
polici	0.6149	0.3826	1.607	0.1080

Table 5- Stepwise forward Belgium

Stepwise forward - Italy				
Variables	Estimate Std	Error	Z value	Pr(>|Z|)
(Intercept)	-1.6089	0.1698	-9.478	< 2e-16 ***
policy	-2.0035	0.6326	-3.167	0.00154 **
emits	1.6877	0.5800	2.910	0.00361 **
european	0.4217	0.1336	3.157	0.00159 **
integr	-0.4242	0.2241	-1.893	0.05841 .
manufactur	-0.5517	0.2709	-2.037	0.04168 *
techniqu	0.2929	0.1150	2.548	0.01084 *

Stepwise forward – Italy (continuing)				
Variables	Estimate Std	Error	Z value	Pr(>|Z|)
earth	0.3197	0.1109	2.883	0.00394 **
part	-0.3314	0.2233	-1.484	0.13771
main	0.4647	0.1901	2.444	0.01451 *
assess	-0.3551	0.2016	-1.761	0.07826 .
term	0.4474	0.1739	2.573	0.01009 *
well	-0.4934	0.2292	-2.153	0.03133 *
allow	0.2792	0.1563	1.786	0.07408 .
activity	-0.5489	0.3096	-1.773	0.07623 .
programm	-0.6062	0.3827	-1.584	0.11317
follow	-0.3276	0.2291	-1.430	0.15284

Table 6- Stepwise forward- Italy

Stepwise forward - France				
Variables	Estimate Std	Error	Z value	Pr(>|Z|)
(Intercept)	-1.7961	0.1646	-10.913	< 2e-16 ***
assess	0.4372	0.1184	3.693	0.000222 ***
techniqu	-0.5498	0.2345	-2.345	0.019024 *
part	0.2760	0.1257	2.196	0.028066 *
full	-0.5871	0.2811	-2.089	0.036747 *
aim	0.3435	0.1322	2.599	0.009361 **
european	0.3107	0.1121	2.772	0.005575 **
two	-0.4466	0.2150	-2.077	0.037802 *
spacecraft	0.2660	0.1089	2.443	0.014574 *
manufactur	-0.2731	0.1534	-1.780	0.075041 .
allow	-0.3473	0.2167	-1.602	0.109089
exist	0.3042	0.1767	1.722	0.085077 .
ground	-0.2322	0.1477	-1.573	0.115818
main	-0.3443	0.2119	-1.625	0.104180
result	0.3196	0.1821	1.755	0.079229 .
demonstr	-0.2200	0.1554	-1.416	0.156769

Table 7 - Stepwise forward- France

Stepwise forward - Great Britain				
Variables	Estimate Std	Error	Zvalue	Pr(>|Z|)
(Intercept)	-1.8881	0.1536	-12.290	< 2e-16 ***
aim	0.3671	0.1279	2.870	0.00411 **
full	-0.8639	0.286	-3.016	0.00256 **
activity	0.6574	0.2166	3.035	0.00240 **
integr	-0.2688	0.1576	-1.706	0.08810 .
earth	0.2152	0.1073	2.006	0.04487 *
main	-0.4299	0.2070	-2.077	0.03782 *
assess	0.1855	0.1114	1.665	0.09591 .
result	0.2829	0.1730	1.635	0.10198
one	0.2692	0.1784	1.509	0.13125

Table 8 - Stepwise forward - Great Britain

For every stepwise result above, please consider the following codes for significance:
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Each ITT will have predicted values per each regression model, in this case, total of five models: one per country..

Prediction using a certain model intends to predict the outcome for new unseen objects. A good prediction is one that accurately predicts such an outcome.

According to G. Shmueli, "Predictive modeling is the process of applying a statistical model or data mining algorithm to data for the purpose of predicting new or future observation" [33].

Although logistic regression model, logit (y)=$\alpha+\beta\chi$ seems like a linear regression model, the underlying distribution is binomial and the parameters, α and β cannot be estimated in the same way as for simple linear regression. As explained in the previous chapter, maximum likelihood will provide values of α and β which maximize the probability of obtaining the data set. The likelihood function is used to estimate the probability of observing the data, using unknown parameters (α and β). "Likelihood" is a probability to predict the observed values of the dependent variable from the observed values of the independent variables [34].

The fitted values predict the chance of success in winning one ITT. For every country, fitted values were calculated using all the observations for that country from a total of 757 observations per country.

For this first study, predicted values and real events (what really happened) were organized in a table using Excel.

The models were created for each country and fitted values from the Stepwise forward method were selected. The predicted (fitted) values were organized from the smaller to the largest number.

Every value indicates the chance of winning the ITT produced by the developed option, using stepwise forward selection procedure. The fitted values vary from "0" to "1", where "1" means 100% (a hundred percent).

Then, for each country all the values bigger than 0,5 were considered. This cut-off point was selected because it indicates a chance of success larger than a purely random event. The values were then organized per country.

Values smaller than 0.05 were ignored, they represent a smaller chance of a certain country award the ITT.

The results include 66 (sixty-six) fitted values larger than 0.5, distributed between the 5 countries, meaning that there are 66 values indicating a higher chance of winning an ITT than a purely random event. We compared the predicted values with the real events, and this comparison can be seen in Table 9.

This study can certainly be constantly improved, with the increase of the number of observations in the dataset of awarded ITT, once ESA monthly publishes and circulates among relevant institutions, as CENTRA/SIM FCUL, this information.

		PREDICTION	REAL WINNER	PREDICTION RIGHT?
4	0,60	FR	GB,FI,IT,FR,BE	1
4	0,77	GB	GB,FI,IT,FR,BE	1
21	0,65	FR	E,NO,GB,FR,BE,CA,	1
21	0,59	IT	E,NO,GB,FR,BE,CA,	1
25	0,60	GB	FR	0
53	0,51	BE	FR	0
68	0,61	FR	FR	1
113	0,88	IT	GB,IT	1
118	0,51	GB	NL	0
135	0,55	IT	ES,IT	1
152	0,78	IT	IT	1
153	0,57	GB	DE	0
154	0,60	GB	DE	0
160	0,63	FR	DE,FR,GB	1
160	0,58	GB	DE,FR,GB	1
168	0,64	FR	FR	1
169	0,59	DE	DE	1
173	0,61	GB	GB	1
181	0,52	DE	PT	0
187	0,62	DE	FR	0
192	0,59	DE	NL	0
193	0,59	DE	CA	0
194	0,59	DE	DR	1
203	0,71	FR	FR	1
211	0,51	IT	IT	1
215	0,55	DE	DE	1
231	0,61	DE	DE	0
231	0,64	IT	IT	1
259	0,56	FR	GB	0
259	0,61	GB	GB	1
275	0,90	DE	DE	1
276	0,57	DE	FR,SE	0
292	0,52	DE	IT	0
306	0,86	FR	CH	0
325	0,62	GB	GB	1
327	0,69	FR	FR	1
337	0,74	DE	GB	0
369	0,58	BE	NL,IRL,GB	0
380	0,55	DE	DE	1
396	0,70	IT	IT,DE	1
409	0,52	IT	IT	1
440	0,60	FR	IT	0
447	0,57	GB	SE	0
453	0,58	GB	IT,PL,CH,FR,GB	1
467	0,52	FR	DE,FR	1
498	0,62	FR	FR	1
531	0,97	IT	IT	1
539	0,55	IT	IT	1
552	0,90	IT	IT	1
567	0,62	IT	ES	0
594	0,59	GB	GB	1
602	0,72	FR	FR	1
602	0,91	IT	IT	1
605	0,87	DE	DE	1
644	0,61	IT	IT	1
662	0,74	FR	FR,GB	1
663	0,62	FR	NL	0
681	0,54	FR	FR	1
709	0,55	FR	GB,IT	0
710	0,53	DE	DE	1
713	0,51	DE	DE	1
720	0,99	IT	IT	1
722	0,52	DE	IT,DE	1
725	0,53	IT	IT	1
743	0,52	FR	FR	1
753	0,58	DE	DE	1

Table 9- Prediction x Real event

The analysis of table 9 shows that 45 observations out of 66 were correctly predicted. This indicates that in around 68% of the cases, the model prediction was correct.
This can be seen in a visual representation that shows clearly the curve of "Real event" versus "Predicted value per observation". A real event can be "0" or "1". It was defined "0" when the prediction went wrong comparing to what really happened. In the same way was defined "1", when prediction was equal the reality. Figure 7 shows this representation. In the X axis, it is possible to find the running number of the observation. And in axis Y, the predicted value. There are 66 observations in total.
In the Y axis, the value changes from 0 to 1, depending on the result of the prediction: right or wrong. Two curves are plotted: The blue curve represents the real event. When the countries win, value is equal "1", when country loses, value is equal "0". The orange curve represents the predicted values for the probability of winning, so that the values vary continuously from 0 to 1. As said before, the figure shows the observations where the prediction was larger than 50% (not random). The comparison of the two curves provide a simple diagnostic to see if the model prediction and the real event followed the same trend.
When we set a cut-off point for the predicted value larger than 0,8, the prediction always worked correctly: if our model predicted a win, the country would win the ITT, although it could win, and our model miss the prediction.

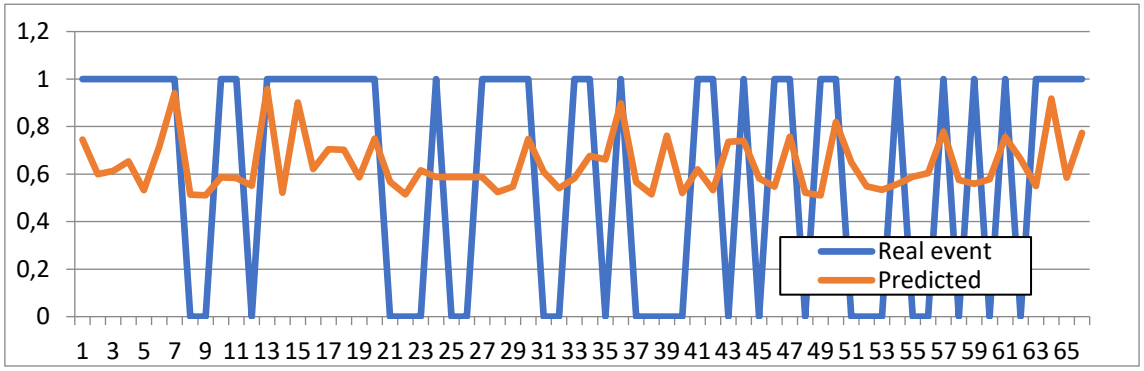

Figure 7 – Real event x Predicted value

Models can always be changed and improved. Using this simple model, we can see that certain words in ESA ITT abstract can help to find if a country has probability of winning.
Using these types of tools, countries as Portugal can choose partners from the country with more chance of winning and optimize its odds in such a competitive environment.
Given a new ITT, its abstract can be studied using the models we developed for all the 5 countries, and using the outcomes of the predictions, our models can help the decision making, in question like: Should I try to contact a partner institution and, if so, from which country?
This way to study using predictions is simpler, using no specific statistical software, just comparing predicted values bigger than 0,5 (not random) with the real event, in other words, if the country "in fact" won or not. One way to evaluate the quality of the fitted value is comparing the predicted value and the observed values. When there is more agreement between the predicted values and the observed values, the model can be considered a better model.
Generally, positive values are equal to "1", and negative values are equal to "0". Positive values that were predicted as positive are called True Positive (TP). Negative values that were predicted as negative are called True Negative (TN). Values predicted as positive and observed as negative are called False Positive (FP) and the ones predicted as negative but observed as positive are false

negatives (FN). Once the observed values/fitted values are classified, the results are presented in a "Confusion Matrix". [35][36]

A confusion matrix (Kohavi and Provost, 1998) contains information about actual and predicted classifications done by a classification system. Performance of such systems is evaluated using the data in the matrix. Figure 8 shows the confusion matrix for a two-class classifier.

The entries in the confusion matrix have the following meaning in the context of our study:

- a is the number of correct predictions that an instance is negative,
- b is the number of incorrect predictions that an instance is positive,
- c is the number of incorrect of predictions that an instance negative, and
- d is the number of correct predictions that an instance is positive.

		Predicted	
		Negative	**Positive**
Actual	**Negative**	**a**	**b**
	Positive	**c**	**d**

Figure 8- General representation of a confusion Matrix

The recall or true positive rate (TP) is the proportion of positive cases that were correctly identified, as calculated using the equation:

$$TP= d/c+d$$

The false positive rate (FP) is the proportion of negatives cases that were incorrectly classified as positive, as calculated using the equation:

$$FP=b/a+b$$

The true negative rate (TN) is defined as the proportion of negatives cases that were classified correctly, as calculated using the equation:

$$TN=a/a+b$$

The false negative rate (FN) is the proportion of positives cases that were incorrectly classified as negative, as calculated using the equation:

$$FN= c/c+d$$

Regarding the confusion matrix, there are two other definitions that are very relevant, namely, Specificity and Sensibility:

Sensibility (S): is the probability of an observation being classified as positive, if it is positive.

$$S=TP/TP+FN$$

Specificity (E): is the probability of an observation being classified as negative, if it is negative.

$$E=TN/TN+FP$$

In our example, we refer to a true observation if it has the condition that we want to test, namely, to be an ITT winner. The observation is false if it has not the condition that is being tested, that is, not win an ITT or be a loser in an ITT.

One way to limit the proportion of false negatives or false positives is defining an adequate "cut-off point".

The choice of the cut-off value determines the rates of true positive (TP), true negative (TN), false positive (FP), and false negative (FN) test results [40]. This cut-off value determines the values for S and E. However, for a given dataset, we cannot increase both S and E at the same time. If we decrease the cut-off value, S increases and E decreases. For a more specific test (by increasing

the cut-off value), you will have a less sensitive test. [37]. A good model is expected to have a high sensibility and a low specificity.
If, we select the Cut-off point where the S curve (sensibility – true positive observations) intercepts the E curve (specificity – true negative observations), different probabilities for each one of the 5 countries with more awarded ITTs will be found.
The cut-off point defines the number of observations which where correctly predicted in certain probability. The Cutoff has a different combination of Se and Sp. Each threshold has an ability to increase the possibility to the target condition to be correctly identified.
The following graphics represent the cut-off point for each country.

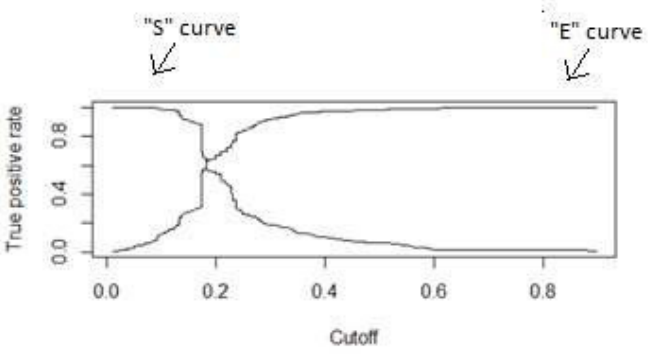

Figure 9- Germany cut-off point

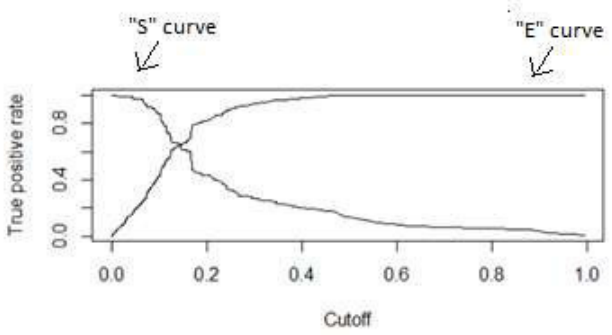

Figure 10- Italy Cut-off point

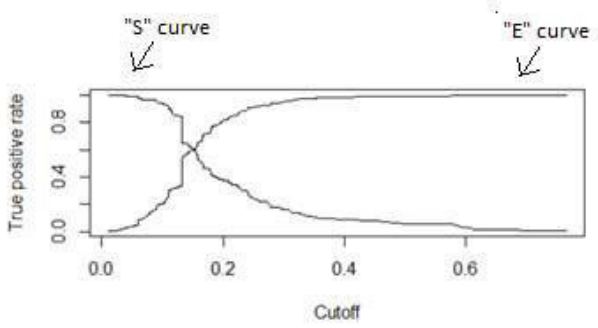

Figure 11- Great Britain cut-off point

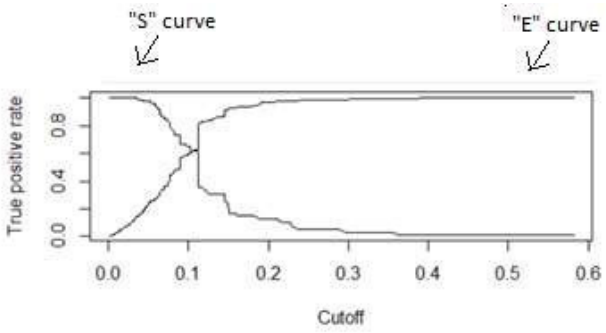

Figure 12- Belgium Cut-off point

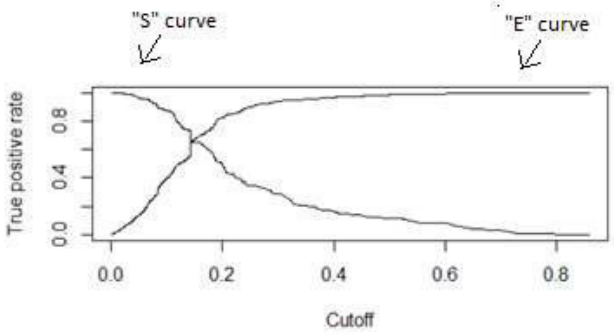

Figure 13- France Cut-off point

In the graphics above, all the cut-off points are defined for the fitted values from all 5 countries.
In figure 9, it is possible to see that the cut-off point for Germany is around 0,2. This means that in 20% of observations, Germany was correctly predicted winner in around 60% of observations (number represented by true positive rate represented in axis Y).
In figure 10, the cut-off point for Italy is around 0,17. This means that in 17% of the observations, Italy was correctly predicted winner in more than 60% of observations (number represented by true positive rate represented in axis Y).
In figure 11, the cut-off point for Great Britain is around 0,17. This means that in 17% of the observations, Great Britain was correctly predicted winner in more than 55% of observations (number represented by true positive rate represented in axis Y).
In Figure 12, the cut off point for Belgium is around 0,10. In 10% of observations, Belgium was correctly predicted winner in more than 60% of observations (number represented by true positive rate represented in axis Y).
In Figure 13, the cut off point for France is around 0,17. In 17% of observations, Belgium was correctly predicted winner in more than 60% of observations (number represented by true positive rate represented in axis Y).
Another way to determine the quality of a model is using the ROC curve[12]. According to T.Fawcett, "A receiver operating characteristics (ROC) graph is a technique for visualizing, organizing and selecting classifiers based on their performance".[38]
In the central part of the graphic, the diagonal represents the exact point where the probability is 50%. If the curve is below this graphic, it is possible to infer that the probability is less than 50%,

[12] A receiver operating characteristic curve, or ROC curve, is a graphical plot that illustrates the diagnostic ability of a binary classifier system as its discrimination threshold is varied.
The true-positive rate is also known as sensitivity. The false-positive rate is also known as the fall-out or probability of false alarm and can be calculated as (1 − specificity).

but clearly this will never happen, because random possibility is 50/50%, “1” or “0”, “right” or wrong”.
A ROC graph is a plot with the false positive rate on the X axis and the true positive rate on the Y axis for the different cut-off points, from 0 to1. The point (0,1) is the perfect classifier: it classifies all positive cases and negative cases correctly. It is (0,1) because the false positive rate is 0 (none), and the true positive rate is 1 (all). The point (0,0) represents a classifier that predicts all cases to be negative, while the point (1,1) corresponds to a classifier that predicts every case to be positive. Point (1,0) is the classifier that is incorrect for all classifications. In many cases, a classifier has a parameter that can be adjusted to increase TP at the cost of an increased FP or decrease FP at the cost of a decrease in TP. Each parameter setting provides a (FP, TP) pair and a series of such pairs can be used to plot n ROC curve [41]. Figures 15 to 18 show the ROC curve for all the five studied countries:

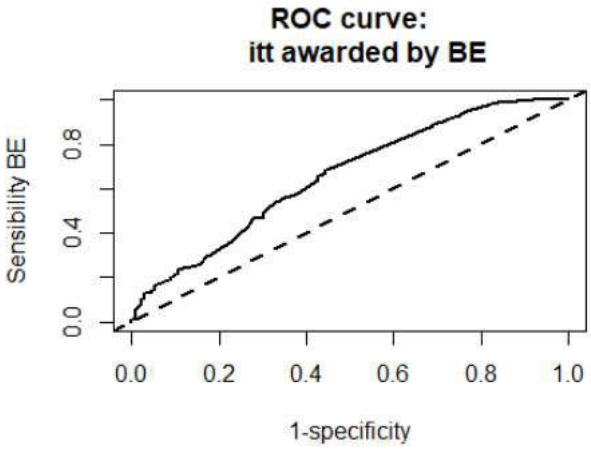

Figure 14- ROC curve Belgium

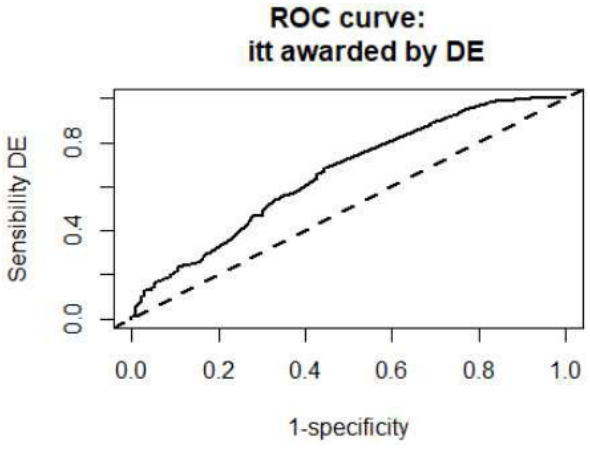

Figure 15- ROC curve for Germany

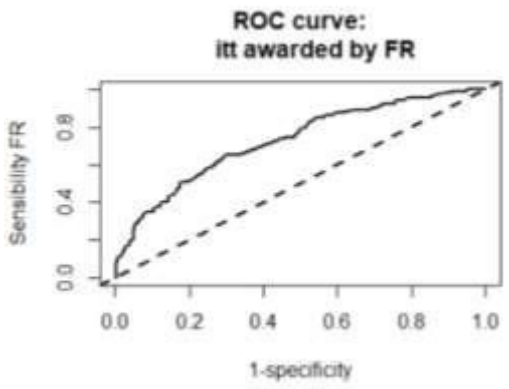

Figure 16- ROC curve for France

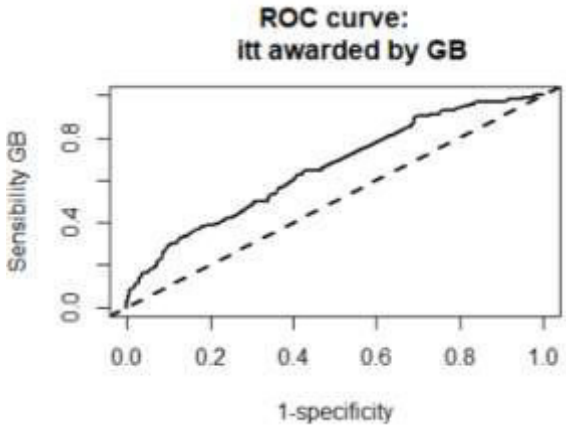

Figure 17- ROC curve for Great Britain

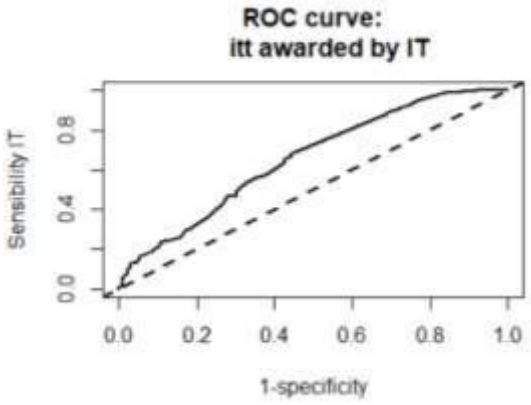

Figure 18- ROC Curve for Italy

The area under a ROC curve is another way to measure “how good” is the statistic model.

As the area under a ROC curve (AUC) is a measure of the usefulness of a test in general, where a greater area means a more useful test.
Continuing with T. Fawcett, Area under roc curve is a unit square (X axis, equal 1 and Y axis equal 1). AUC will always be more than 0.5, because there is no classifier smaller than 0.5 (random). Every event, without any study can receive two values: right or wrong, 0 or 1, no or yes. These events have 50% probability to happen. That is the reason why, there is no sense to say a classifier less than 0.5.
AUC of a classifier is equivalent to the probability that the classifier will rank a randomly chosen positive instance higher than a randomly chosen negative instance.

Considering this definition, the best model should be the one with largest AUC. The results for AUC were calculated in the R program, and were as follows:

- France [FR]- 0.727368
- Italy [IT] - 0.7255399
- Belgium [BE]- 0.6729561
- Great Britain [GB]- 0.6569059
- Germany [DE]- 0.656492

As presented, the largest AUC among the 5 models is from France.
The AUC was 0.727368, representing that the chance of success using the developed model is 72,7368%. Using this model, the chance of a right prediction will be about ¾. This is a very interesting outcome, as our model has a chance that is 22% above a random model.
The other 4 countries also had AUC with levels greater than 65%, meaning that each model has a probability to succeed which is at least 15% larger than a purely random prediction.
Another method to verify the chance is the odds ratio.

$$\text{odds ratio} = \frac{\text{Odds}(Y=1|X=1)}{\text{Odds}(Y=1|X=0)}$$

This is interpreted as the odds that Y = 1 when X = 1 versus the odds that Y = 1 when X = 0. If the odds ratio is 2, then the odds that Y = 1 are two times higher when X = 1 versus X = 0.
Why bother with an odds ratio, instead of probabilities? We work with odds because the coefficient in b_j the logistic regression is the log of the odds ratio for X_i. [39]
According to H. Park, the OR (odds ratio) represents the odds of an outcome having or having not a condition that is being studied.
OR=1 indicates that exposure to a certain factor does not affect the odds of the outcome. OR>1 indicates that the exposure is associated with higher odds of the outcome. OR<1 indicates that exposure is associated with lower odds of outcome.[34]
In this study, the odds ratio for each one of the 60 variables per country was calculated.
If words have an OR value bigger than 1, that indicates more chance to have success, in this case, more chance of winning an ITT.
Words with an OR value smaller than 1 means there is less chance of success. If they appear, the chance of winning decreases.

	ODD.BE		ODD.DE		ODD.FR		ODD.GB		ODD.IT
(Intercept)	1.260173e-01	(Intercept)	0.2002272	(Intercept)	0.1721696	(Intercept)	0.1333686	(Intercept)	2.051258e-01
aim	1.400100e+00	aim	1.0937348	aim	1.3947098	aim	1.3764476	aim	1.106208e+00
applic	9.795335e-01	applic	0.9036232	applic	0.8640699	applic	1.0833302	applic	8.557643e-01
capabl	1.358722e+00	capabl	1.1317739	capabl	0.8575973	capabl	0.9503845	capabl	1.293420e+00
differ	1.198544e+00	differ	1.1073080	differ	0.8561203	differ	0.9153680	differ	1.010585e+00
follow	1.004005e+00	follow	1.3114704	follow	0.9960502	follow	0.9251127	follow	6.814808e-01
ground	7.848256e-01	ground	1.3246385	ground	0.7477550	ground	1.0621169	ground	1.208261e+00
identifi	8.507329e-01	identifi	1.2815938	identifi	0.9390781	identifi	1.0043496	identifi	8.340262e-01
integr	1.217358e+00	integr	1.0698761	integr	0.9867116	integr	0.7185541	integr	6.189551e-01
part	9.933493e-01	part	1.1183199	part	1.3247891	part	0.8001379	part	7.010729e-01
potenti	1.099938e+00	potenti	0.8083507	potenti	1.3432216	potenti	0.9212438	potenti	1.072142e+00
propos	8.340927e-01	propos	0.8137603	propos	1.2032862	propos	0.8566392	propos	1.158763e+00
specif	1.146826e+00	specif	0.7849377	specif	0.9478806	specif	1.1886581	specif	9.201313e-01
time	9.187076e-01	time	0.9546893	time	1.1179201	time	1.0392608	time	9.573525e-01
allow	1.057566e+00	allow	1.0686870	allow	0.6885645	allow	0.8730633	allow	1.190528e+00
assess	6.336677e-01	assess	1.0429706	assess	1.4722396	assess	1.2351993	assess	6.076423e-01
contractor	1.328308e+00	contractor	0.9509390	contractor	1.2096426	contractor	1.2131877	contractor	8.633778e-01
european	1.153452e+00	european	0.9559233	european	1.3395093	european	0.8809075	european	1.625794e+00
exist	8.831909e-01	exist	1.0707554	exist	1.2801313	exist	0.9993753	exist	7.696224e-01
increas	1.068655e+00	increas	0.9553451	increas	0.9840855	increas	1.0566597	increas	9.211503e-01
limit	6.542659e-01	limit	0.4656155	limit	1.1269644	limit	1.1860824	limit	9.311415e-01
order	8.845194e-01	order	1.4952350	order	1.1612542	order	0.9195751	order	1.213060e+00
power	8.749079e-01	power	0.9831669	power	0.8857992	power	1.0682996	power	1.097502e+00
product	1.095927e+00	product	1.1729835	product	1.0095768	product	1.0938953	product	8.754423e-01
result	6.766293e-01	result	1.1646402	result	1.4431619	result	1.3153754	result	1.275540e+00
techniqu	1.120387e+00	techniqu	1.0392466	techniqu	0.5708271	techniqu	0.9984854	techniqu	1.378423e+00
earth	1.067520e+00	earth	0.8870124	earth	1.0675134	earth	1.1643337	earth	1.442309e+00
futur	1.037479e+00	futur	0.7039205	futur	1.2308873	futur	1.1690096	futur	1.191673e+00
well	1.134148e+00	well	0.8619023	well	1.1816030	well	1.0344114	well	6.043771e-01
within	7.427574e-01	within	1.2537401	within	0.7584572	within	1.1513292	within	8.568493e-01
avail	8.471843e-01	avail	1.2004607	avail	0.8196354	avail	0.8059909	avail	1.021493e+00
entiti	5.226623e-01	entiti	2.0356522	entiti	1.4826157	entiti	1.0817954	entiti	1.164766e+00
generat	6.743904e-01	generat	0.6547097	generat	0.8353441	generat	1.2248430	generat	1.021120e+00
improv	5.621152e-01	improv	0.9013787	improv	1.1962583	improv	1.0128469	improv	9.556496e-01
one	1.126235e+00	one	1.0017424	one	1.1710849	one	1.2774484	one	7.168171e-01
programm	1.214707e+00	programm	1.1576248	programm	0.6930183	programm	1.3059318	programm	4.789728e-01
activiti	1.968853e+00	activiti	1.2284272	activiti	0.2210628	activiti	2.5087198	activiti	9.535610e-01
activity	1.332236e+00	activity	0.7513199	activity	0.9250648	activity	2.3100313	activity	5.839933e-01
concept	8.559156e-01	concept	1.3740598	concept	0.9486536	concept	1.0501434	concept	9.375660e-01
emits	1.686651e+00	emits	0.9990254	emits	0.8497047	emits	1.0285480	emits	8.540899e+00
full	9.367073e-01	full	1.6039899	full	0.6946425	full	0.5795502	full	1.019403e+00
incl	1.025635e-06	incl	3.1773650	incl	0.1011332	incl	1.6094140	incl	4.473539e-01
industrial	1.896489e+00	industrial	0.5230674	industrial	9.8704342	industrial	8.9802511	industrial	2.598440e-06
news	1.109135e-01	news	0.1316390	news	4.4215627	news	0.8499147	news	3.611500e-01
nonprimes	1.189175e+00	nonprimes	4.7764213	nonprimes	0.2837834	nonprimes	0.1874721	nonprimes	2.164366e+06
pleas	1.293032e+00	pleas	1.0953020	pleas	0.4260843	pleas	0.4100378	pleas	8.338020e-01
polici	2.935965e+00	polici	0.6935282	polici	0.8828137	polici	0.7433389	polici	3.311012e-01
policy	1.086851e+00	policy	1.2232350	policy	1.4881408	policy	0.6155880	policy	1.368783e-01
restrict	5.199937e-01	restrict	1.1209389	restrict	1.2401809	restrict	0.5740807	restrict	1.296781e+00
nonprim	4.234842e+05	nonprim	0.4170749	nonprim	3.1907976	nonprim	0.9206427	nonprim	2.141054e+00
term	7.251587e-01	term	1.2610057	term	0.8345661	term	1.0343061	term	1.492402e+00
demonstr	1.261880e+00	demonstr	1.0048733	demonstr	0.7883512	demonstr	1.0507701	demonstr	8.687824e-01
manufactur	1.036585e+00	manufactur	0.9751913	manufactur	0.7812206	manufactur	1.0826932	manufactur	6.024824e-01
main	8.125023e-01	main	0.8158361	main	0.6719514	main	0.6769784	main	1.574314e+00
particular	1.010196e+00	particular	0.8458237	particular	0.6930280	particular	0.8199757	particular	8.810627e-01
spacecraft	9.979339e-01	spacecraft	0.9129528	spacecraft	1.3173831	spacecraft	0.9802446	spacecraft	9.424316e-01
possibl	1.014025e+00	possibl	0.7864972	possibl	1.2172157	possibl	0.8844351	possibl	1.290233e+00
select	7.703554e-01	select	0.9231932	select	0.8345703	select	1.0712105	select	8.899354e-01
two	1.513420e+00	two	0.8809230	two	0.6278781	two	1.0509373	two	1.109669e+00
analysi	6.269243e-01	analysi	0.9561952	analysi	1.0250432	analysi	0.9388225	analysi	1.187058e+00
valid	8.837597e-01	valid	1.0744759	valid	0.9898086	valid	1.043887	valid	8.613006e-01

Figure 19- ODD Ratio for all 5 countries

Comparing this 5 tables with the words, it is possible to infer that some words, when appear in the ITT, increase the chance of a certain country to win the ITT.
There are some interesting highlights about which word “should” appear, and which word “must never” be written in the ITT abstract.
For France, if the word “industrial” appears in the ITT abstract, the chance of a French company awarding the bid, increases more than 9 times. In the other side, if the word “nonprimes” appears, the chance of winning decreases about 62%. It makes sense, regarding the fact that France has big industrial companies as Airbus, and normally big companies are always the prime contractor and normally dominate the consortium.
For France, the word “news” increases the chance in more than 400%, in the other hand, this word decreases the chance of the other 4 countries.
For Germany, if the word “nonprimes” appears in the ITT abstract, the chance of a German company awarding the bid, increases more than 4 times in the other side, if the word “industrial” appears, the chance of Germany winning decreases about 48%.
Another example is the word “incl”, that raises Germany chance in more than 300% and decreases France chance in more than 85%.
These facts reinforce our firsts insights derived from the exploratory analysis in the first chapter about the negative correlation between the 5 countries considered herein.
For Italy if the word “emits” appears in the ITT abstract, the chance of an Italian company awards the bid, increases more than 8 times. In the other side, in the case of Italy the word “industrial” decreases the chance of winning in more than 90%. Completely opposite comparing to France.
For Belgium, the word “polic” increases the chance of winning in more than 200%. Belgium has more similarities with Germany than with France.
For Great Britain, the word “nonprimes” decreases the chance of winning in more than 80%.
Many words aren´t representative to increase the chance of winning.
Some examples are:

- “main”- decreases the chance of Belgium, Germany, France and Great Britain countries in percentages between 20-30%, and increases about 50%, Italy chance of winning.
- “Spacecraft”- decreases the chance of Belgium, Germany, Italy and Great Britain countries in percentages around 10%, and increases about 30%, France chance of winning.
- “valid”- decreases the chance of Belgium, France and Italy in percentage between 5- 15%, and increases Germany and Great Britain countries in percentages around between 4- 8% chance of winning.
- “concept”- decreases the chance of Belgium, France and Italy in percentage between 5- 15%, and increases Germany and Great Britain countries in percentages around between 5- 30% chance of winning.

The odds ratio from all the five countries can also confirm that there are relations between certain words in the abstract ITT with the chance of winning an ITT.
Possibly, the developed models can be improved year by year including more observations in the dataset, and iteratively refining the choice of words as more data is considered.

IV – EXPLORATORY CLUSTER ANALYSIS

After the developed work described in chapters 1, 2 and 3, text mining analysis will focus in using clustering techniques to search clusters of the document as represented by words, and check if there is any correlation between these clusters and winner countries.
Clustering is the process of sectioning a group of objects or data into a collection of relevant and understandable subclasses. Clustering is used to make a set of similar documents and files. Clustering techniques separates records from a dataset into groups in such a way that themes in a cluster are more similar while themes between different clusters. Methods of clustering are mainly classified into Hierarchical and Non-hierarchical, or Partitional clustering. [39]
Hierarchical methods build the clusters by recursively partitioning the instances in either a top-down or bottom-up fashion, using some measure of the similarity between the data points (in our case, documents). The result of these methods can be visualized as a dendrogram.[40]
According to Oded Maimon & Lior Rokach in "Data Mining and Knowledge Discovery Handbook", "The partitional or non-hierarchical document clustering approaches attempt a flat partitioning of a collection of documents into a *predefined* number of *disjoint* clusters". When using partitional clustering, the number of clusters is pre-defined, differently from hierarchical methods. The major number of those methods are iterative and the single pass methods are usually used in the beginning of a reallocation method to produce the first partitioning of the data.
The partitional clustering algorithms use a feature vector matrix[13] that can be directly identified with a DTM matrix and produce the clusters by optimizing a criterion function, that is, maximize the sum of the average pairwise cosine similarities[14] between the documents assigned to a cluster and minimize the cosine similarity of each cluster centroid to the centroid of the entire collection. There are many criterion functions that can affect the clustering solution and the overall quality depends on how each one of them can correctly operate dataset with clusters of different densities and how they produce balanced clusters.[41].

The partitioning method constructs k clusters from the data respecting the following conditions:

- Each cluster consists of at least one object n and each object k must be belong to one cluster. This condition implies that: $k \leq n$

- Different clusters cannot include the same object, and the union of the constructed k groups corresponds to the full data set. [42]

Some clustering packages in R to analyze datasets are:

- Cluster: for computing Partitional Clustering [43];
- Factoextra: which will be used to visualize clusters;
- Dendextend: for comparing two dendrograms;
- Stats: computing K-means;

There are many methods of hierarchical clustering. In this work we used two different types of m ethods:

- Agglomerative clustering: AGNES (Agglomerative Nesting).
  This method works in a bottom-up manner where each object is initially considered as a single-element cluster (leaf). At each step of the algorithm, the two clusters that are the most similar are combined into a new bigger cluster (nodes). This procedure is iterated until all points are members of just one single big cluster (root). The result is a tree that can be plotted as a dendrogram.

[13] Each row of the feature vector matrix corresponds to a document and each column to a term. The ij-th entry has a value equal to the weight of the term j in document i.
14 Cosine similarity measures the similarity between two non-zero vectors of an inner product space that measures the cosine of the angle between them. The cosine of 0° is 1, and it is less than 1 for any angle in the interval (0,π] radians.

- Divisive hierarchical clustering: DIANA (Divisive Analysis). This approach works in a top-down manner. The algorithm is an inverse order of AGNES. It begins with the root, in which all objects are included in a single cluster. At each iteration, the most heterogeneous cluster is divided into two. The process runs until all objects define their own cluster.

There are many partitional clustering methods used to classify observations. Some of them are:

- K-means - The most common partitional clustering algorithm. It uses the concept that the center of the cluster, "centroid", can represent the cluster. The algorithm starts by selecting k cluster centroids, or number of clusters. After that, each element is classified in a certain cluster, respecting the cosine distance between the element (in our case, abstract from ESA ITT and the cluster centroid. The document will be part of the cluster, defined according the smallest distance. After all elements classified and assigned to clusters, a new cluster centroid is calculated and all the process runs again, until some criterion is met.[44]
- K-medoids clustering or PAM (Partitioning Around Medoids, Kaufman & Rousseau, 19 90), in which, each cluster is represented by one of the objects in the cluster. PAM is less sensitive to outliers compared to k-means. [43]

We analyzed clusters using different R tools. The original dataset was cleaned, organized and transformed in a DTM as explained in chapter 1.
The DTM was organized in a manner where rows are the documents and columns are the terms (in this case the 60 selected terms used in this dissertation and previously defined). Then, we clustered this DTM. The first dendrogram, in Figure 20, shows the clusters formed by the 757 documents of our dataset. The numbers in each branch of the dendrogram represents the observation number (ITT awarded). We can promptly see some major clusters of ITTs.

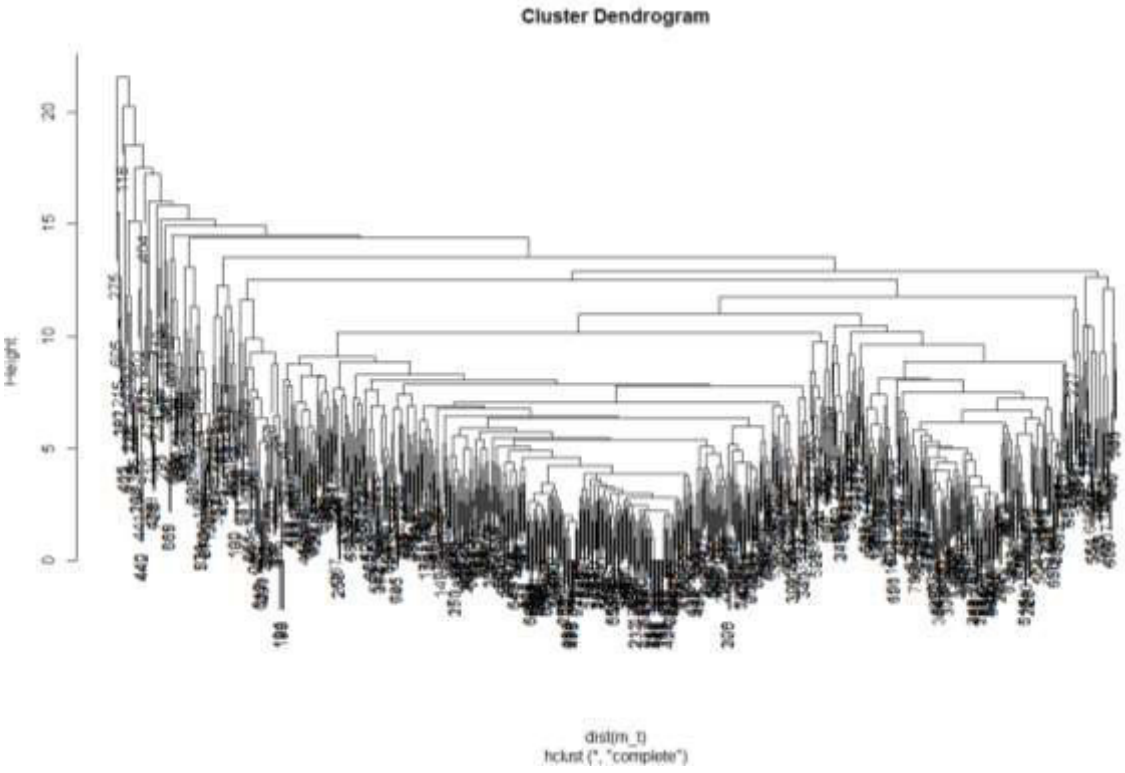

Figure 20- Hierarchical dendrogram of ESA ITTs.

The hierarchical clustering can adopt different linking methods as, for example, complete, ward, single linkage clustering and average linkage clustering. The most common types methods are:

- Maximum or complete linkage clustering: Pairwise dissimilarities between the elements in cluster 1 and the elements in cluster 2 are computed. It is considered the largest value (maximum value) of these dissimilarities as the distance between the two clusters. It tends to produce rather compact clusters.
- Minimum or single linkage clustering: It is the same procedure of the maximum linkage clustering, but considering the smallest distance of the dissimilarities, instead of the maximum value. It tends to produce long, "loose" clusters.
- Mean or average linkage clustering: It is the same procedure of the maximum and minimum linkage clustering methods, but considering the average of these dissimilarities distance, instead of the maximum or minimum value.
- Centroid linkage clustering: This method computes the dissimilarity between the centroid for cluster 1 (a mean vector of length equal to the number of variables, p) and the centroid for cluster 2.
- Ward's minimum variance method: This technique minimizes the total within cluster variance. In every step, the pair of clusters with minimum between-cluster distance are merged. [58]

For this exploratory analysis, we adopted the Complete method, as implemented in the R instruction "HClust" using the method "complete".

In this first dendrogram in Figure 20, it is possible to identify that in the left side there are clusters with a few numbers of documents. In the middle, there are clusters with a higher number of documents, in the right side, the behavior is like the left side: few documents inside smaller clusters in comparison with the large central cluster. What additional information can we infer based on this dendrogram? Each leaf corresponds to one observation. As we move up the tree, observations that are like each other are combined into branches, which are themselves fused at a higher height. The height of the fusion, provided on the vertical axis, indicates the (dis)similarity between two observations. The higher the height of the fusion, the less similar the observations are.

Conclusions about the distance of two observations can be drawn based on the height where branches containing those two observations first are fused. We cannot use the proximity of two observations along the horizontal axis as a criterion for their similarity.

In chapter 1, a correlation matrix was developed for the 60 more frequent terms. Now, using clustering it was possible to define a correlation matrix between the abstracts from the 757 observations (ITT abstract). We adopt the Pearson method to plot the correlation based on the measured distance. The Pearson correlation and distance measures the degree of a linear relationship between two profiles [45]:

$$d_{cor}(x,y) = 1 - \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

Figure 21 shows the result of this analysis. It is possible to notice that the documents text has relation between each other, as red indicates high similarity (i.e.: low dissimilarity), while blue corresponds to low similarity. The color level is proportional to the value of the dissimilarity

between observations: pure red if dist (xi, xj) = 0 and pure blue if dist (xi, xj) = 1. Objects belonging to the same cluster are displayed in consecutive order.

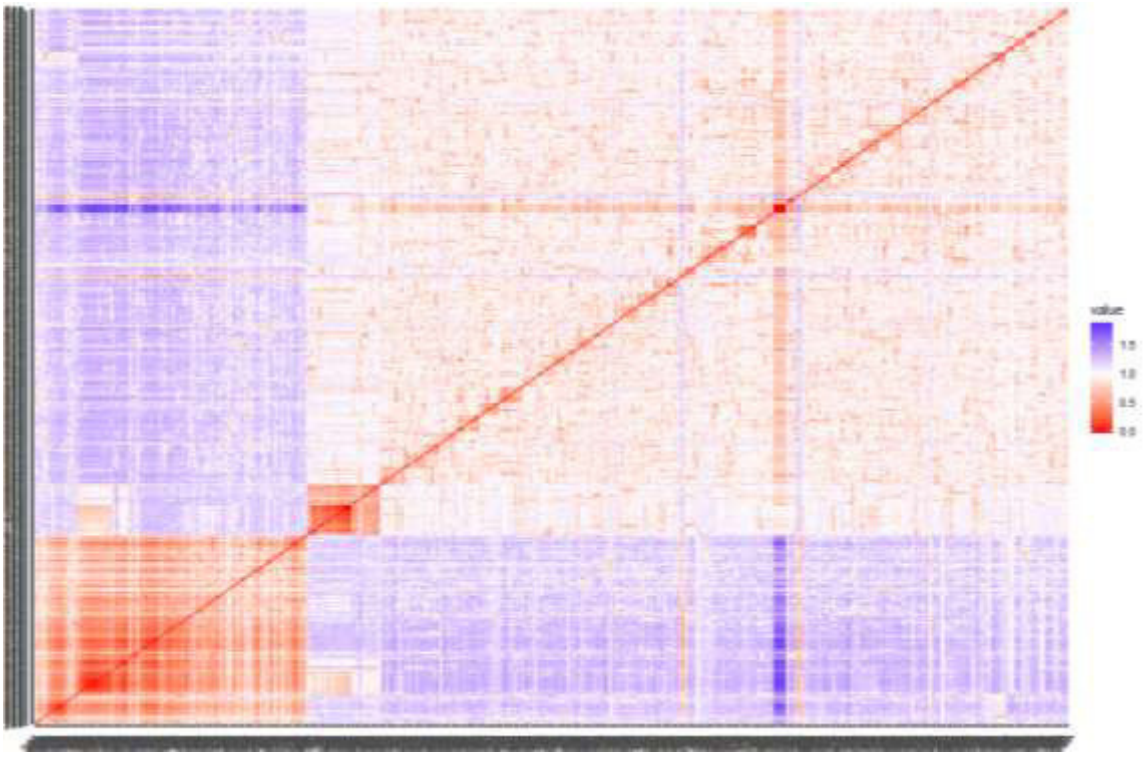

Figure 21- Correlation matrix from all ITT abstracts

Figure 21 shows the tendency for clustering for all ITT abstracts: redder, more similarity; blue color corresponds to more different observations, that is, dis(similarity) is large. Using Figure 21, we can infer that the tendency for clustering is bigger than no clustering. The major area of the plotted correlation matrix is red. So, using both techniques, the dendrogram and the correlation matrix, it was possible to conclude that there is a clustering tendency in the ITT abstracts. Thus, perhaps also countries cluster with awarded ITTs.

We studied different clustering techniques, namely:

Hierarchical: Agglomerative Nesting (AGNES) and Divisive Analysis (DIANA);

Non-hierarchical: K-means and Partitioning Around Medoids (PAM)

Agglomerative Nesting (Agnes)

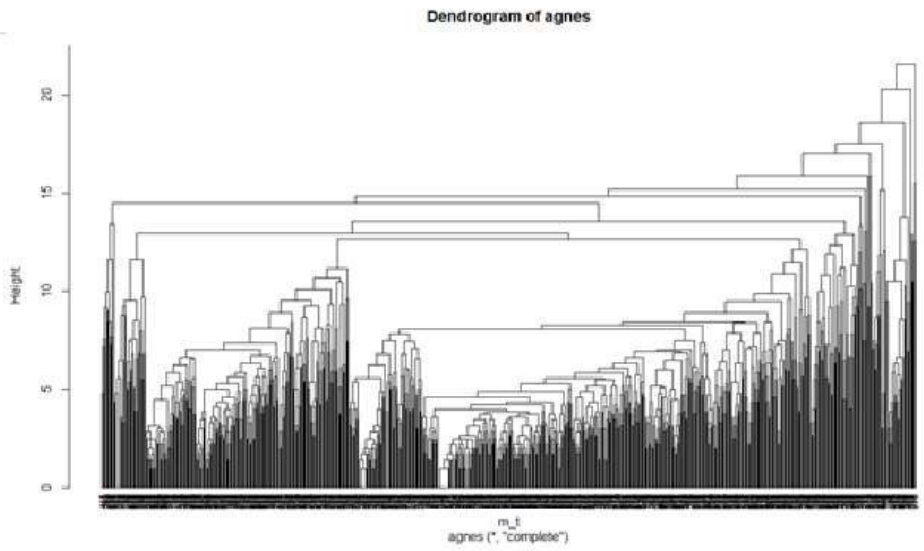

Figure 22- AGNES clustering

The agglomerative coefficient (AC) for AGNES method measures the clustering structure of the dataset. AC grows with the number of observations; this measure should not be used to compare datasets with very different sizes. The agglomerative coefficient measures the amount of clustering structure found (values closer to 1 suggest strong clustering structure).[46]
In this case, agglomerative coefficient is 0.8101603
Considering the definition above, it is possible to conclude that our dataset has a strong clustering structure, more than 80%.

Divisive Analysis (DIANA)

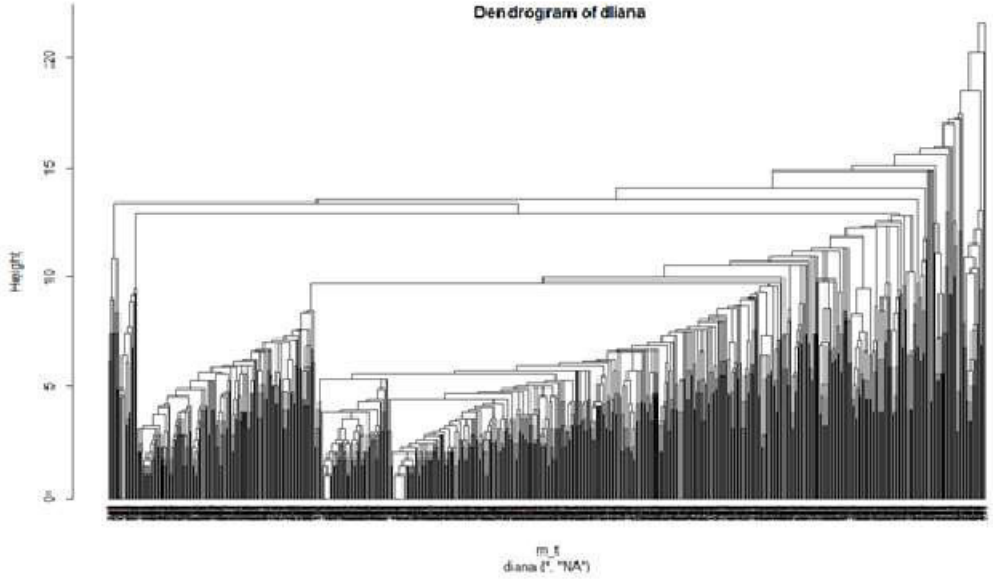

Figure 23- Dendrogram of DIANA

The divisive coefficient measures the clustering structure of the dataset, and in this case, the divisive coefficient is 0.796633

Considering the definition above, it is possible to conclude that our dataset has a strong clustering structure, almost 80%. Comparing the two hierarchical methods, it is possible to say that AGNES resulted in a stronger clustering structure than DIANA. However, the difference between the results obtained by DIANA and AGNES is quite small and, thus, any of the two methods can be chosen.

In the case of non-hierarchical methods, it is necessary to define the number of clusters. The R package "clValid" offers three types of cluster validation: internal and stability.

According to G. Brook et al., in "Journal of Statistical Software", "the stability measures compare the results from clustering based on the full data to clustering based on removing each column, one at a time (Datta and Datta 2003; Yeung et al. 2001)". These measures work well when the data are highly correlated.

The Internal validation measures consider only the dataset and the clustering partition as input and use intrinsic information in the data to assess the quality of the clustering.

For Internal validation, we selected measures that reflect the compactness, connectedness, and separation of the cluster partitions.

According, Handl et al. 2005," Connectedness relates to what extent observations are placed in the same cluster as their nearest neighbors in the data space and is here measured by the connectivity".

Compactness assesses cluster homogeneity, usually by looking at the intra-cluster variance, while separation quantifies the degree of separation between clusters (usually by measuring the distance between cluster centroids).

Compactness and separation reflect opposite trends. Compactness increases with the number of clusters and separation decreases. The Dunn index (Dunn 1974) and silhouette width (Rousseeuw 1987) are both examples of non-linear combinations of the compactness and separation, and together with the connectivity they consist the three internal measures available in clValid. [47]

In this thesis the Silhouette parameter was chosen to validate the number of clusters.

Silhouette refers to a method of interpretation and validation of consistency within clusters of data. The technique provides a graphical representation of how well each object has been classified

Silhouette is a method of interpretation and clustering validation consistency. This technique provides a graphical representation of how objects has been classified [48].

The silhouette width is the average of each observation's silhouette value. This value measures the degree of confidence in the clustering assignment of a observation. Values near "1" means well-clustered observations and values near "-1" means poorly clustered observations having values. For observation i, it is defined as:

$$S(i) = \frac{b_i - a_i}{\max(b_i, a_i)},$$

where a_i is the average distance between i and all other observations in the same cluster, and b_i is the average distance between i and the observations in the "nearest neighboring cluster" i.e.,

$$a_i = \frac{1}{n(C(i))} \sum_{j \in C(i)} dist(i,j), \quad b_i = \min_{C_k \in \mathbb{C} \setminus C(i)} \sum_{j \in C_k} \frac{dist(i,j)}{n(C_k)},$$

where C(i) is the cluster containing observation i, dist(i; j) is the distance (e.g. Euclidean) between observations i and j, and n(C) is the cardinality of cluster C. Silhouette values fit between the interval [-1; 1] and should be maximized.
In R we used the silhouette from the "Cluster" package.[47]
For all the non-hierarchical methods selected for this thesis, we used silhouette to define the optimal cluster number. High average silhouette width indicates a good clustering.
According Kaufman and Rousseeuw,1990 "The optimal number of clusters k is the one that maximizes the average silhouette over a range of possible values for k ".
The R packages "factoextra" and "cluster" provide a convenient solution to estimate automatically the optimal number of clusters: they just run the clustering method using different values for the number of clusters, compute the silhouette parameter and determine the highest value. Figures 24 and 25 show the silhouette as a function of the number of clusters.

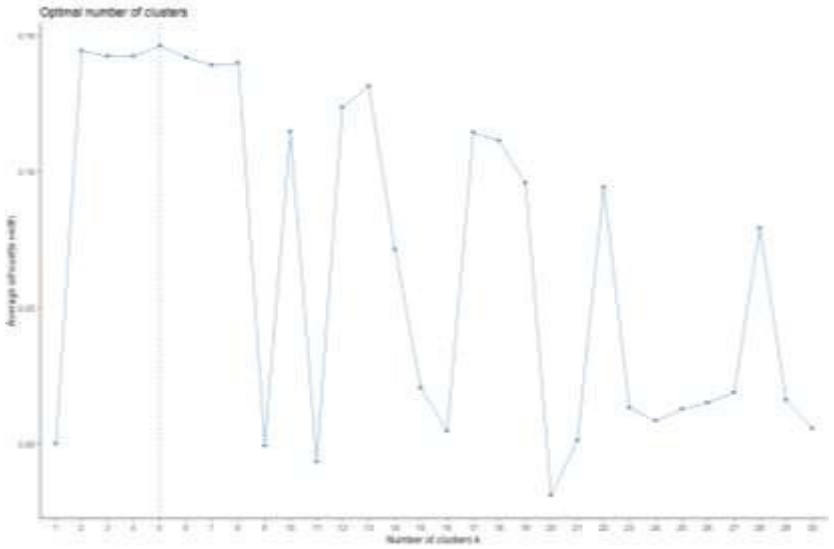

Figure 24- Silhouette value in function of the number of Kmeans clusters

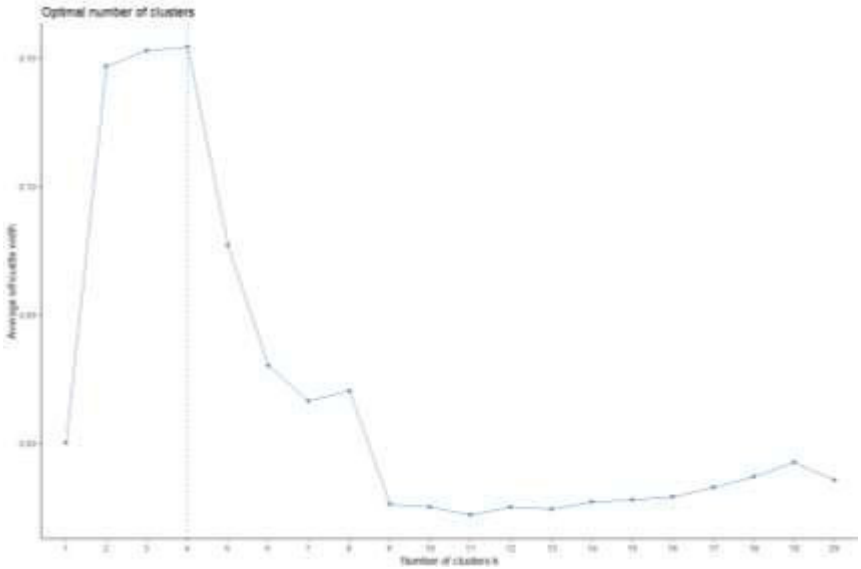

Figure 25- Silhouette value for a range of numbers of PAM clusters

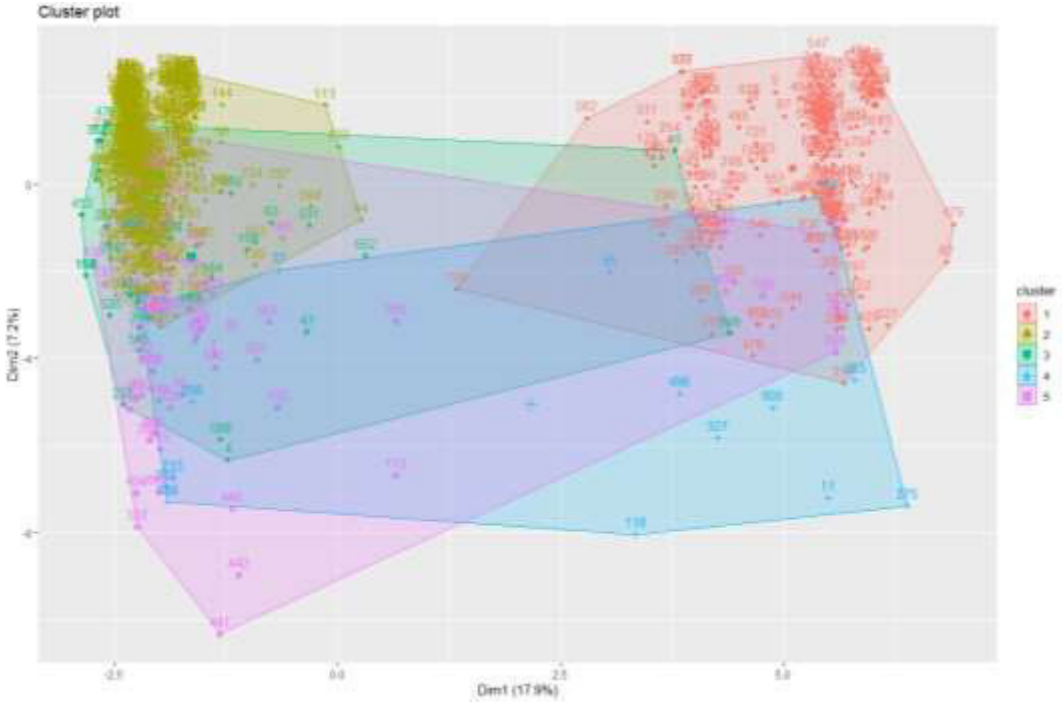

Figure 26- Cluster- Kmeans

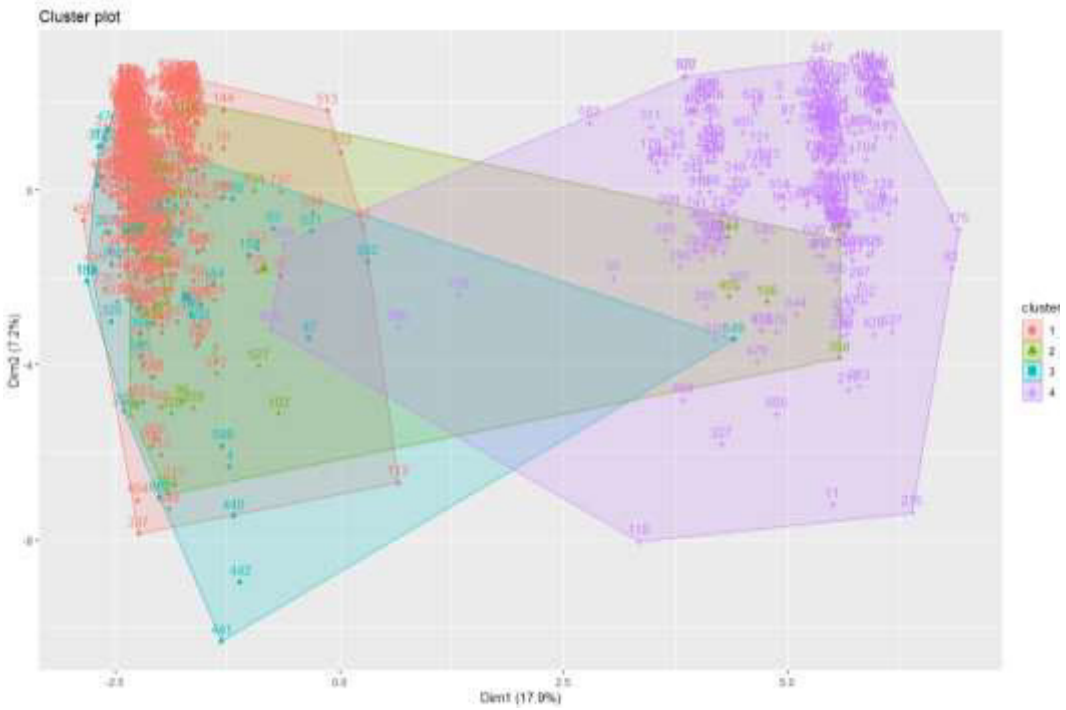

Figure 27- Clusters PAM

As shown above, different methods result in different silhouettes and, consequently, different cluster numbers, albeit the difference (4 or 5 clusters) is not big.
From this, we may conclude that the database can be naturally grouped into different groups based on text alone, and that these different groups define clusters that can correlate with other variables as, possibly, the countries. We may also say that this holds no matter the method adopted. These clusters represent ITTs awarded by countries part of ESA.
The analysis above was performed considering as the original DTM the dataset.
We performed then some analysis, but the results were not satisfactory. Figure 26 shows the results using Kmeans. In this method it is necessary to define the cluster's number and according to the silhouette parameter, the optimal number of clusters is 5.
However, we can easily see that clusters 1 and 2 have significant internal clustering structure, once the low value indicated by silhouette did not enabled the method to split. In cluster 1, represented in red, there are clear agglomerations in the right corner. In cluster 2, represented in green, there is a clear agglomeration in the left corner.

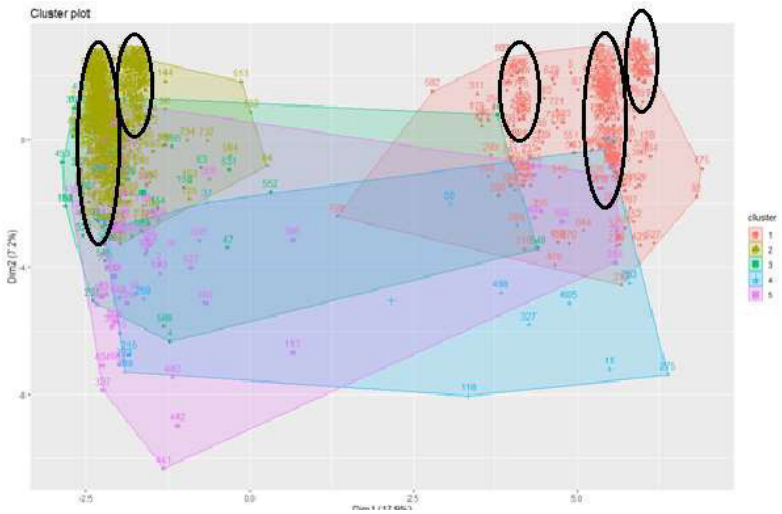

Figure 28 - Kmeans - clusters defined inside others clusters

Figure 27 shows the results using PAM. In this method it is also necessary to define the cluster´s number which optimal value, according to the silhouette parameter, is 4. Inside clusters 1 and 4 we have other clusters that were not separated. In cluster 1, represented in red, there is a clear agglomeration in the left corner. Cluster 4, represented in purple, presents a clear agglomeration in the right corner.

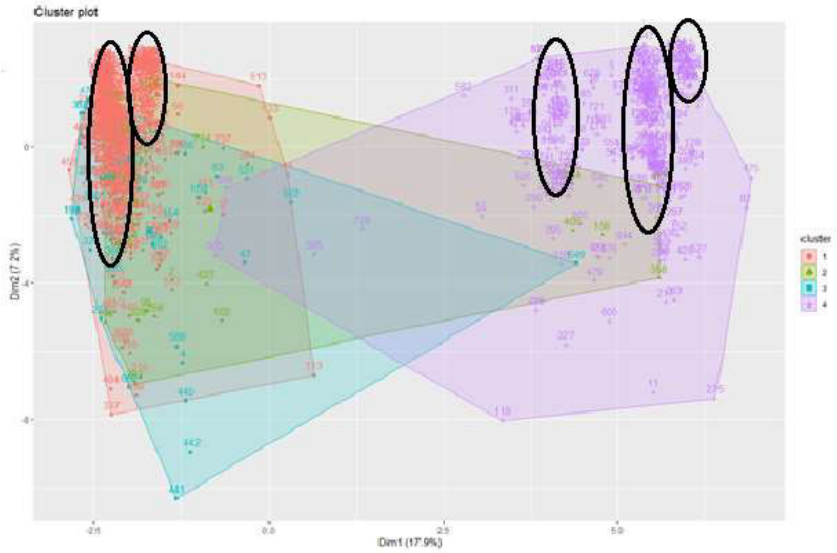

Figure 29- PAM- clusters defined inside other clusters

Considering the results were not satisfactory, we proceeded to test a possible dimensionality reduction, prior to the clustering method. Thus, we used a linear transformation based on Principal Component Analysis (PCA).

Principal component analysis (PCA) is a multivariate technique that analyzes a data table in which observations are described by several inter-correlated quantitative dependent variables. Its goal is to extract the important information from the table, to represent it as a smaller set of new orthogonal variables called principal components [49].

According to I.T. Jolliffe, "Principal Component Analysis", the central idea of principal component analysis (PCA) is to reduce the dimensionality of a data set." [50]. It is normal that dataset have many variables that has no relevant information to add. Using PCA, the dataset is transformed into a new set of variables (note that each variable is a dimension, and when we reduce dimensions, in fact, we are reducing the number of variables). This smaller dimension new dataset consists of a new set of variables, the principal components (PCs), which are uncorrelated, and ordered so that the first few retain most of the variability present in all the original variables.[49]

The original dataset has 60 dimensions, corresponding to the words previously selected: each word is equivalent to a dimension, and each document defines a point in a 60-dimensional space. In this study we considered 10 dimensions, reducing 50 dimensions from the original dataset.

Using "Stats" Package from R, the dataset was converted into a new dataset, with 10 dimensions, that is, 10 variables. After that, we used kmeans again to look for clusters in this transformed dataset.

As before, we used the silhouette method to discover the optimal number of clusters.

The optimal number is plotted in Figure 30.

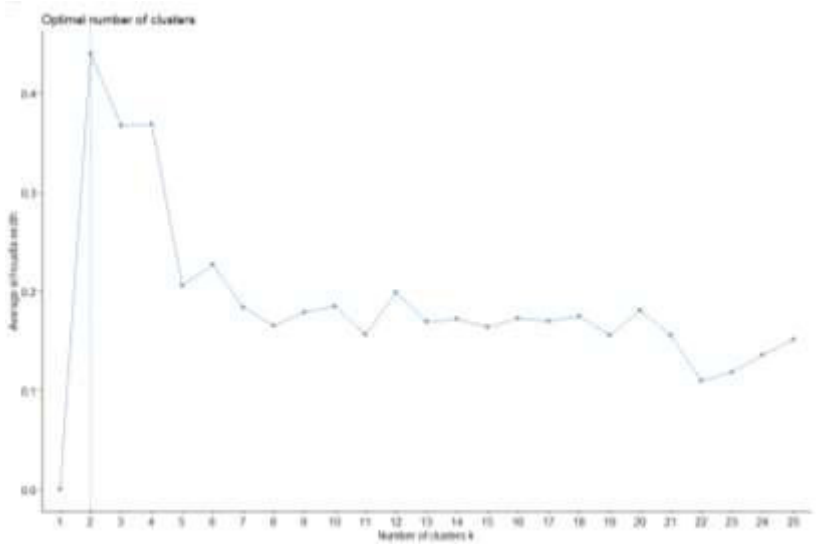

Figure 30- Optimal cluster numbers- PCA

The plotted graphic defines as optimal number of 2. However, 2 is clearly too small considering the dataset size and previous results and so we decided to adopt the second-best peak of the silhouette analysis. The second-best number of clusters in this case is also number 4, as previously seen, and this was the number of clusters chosen for the new clustering definition.

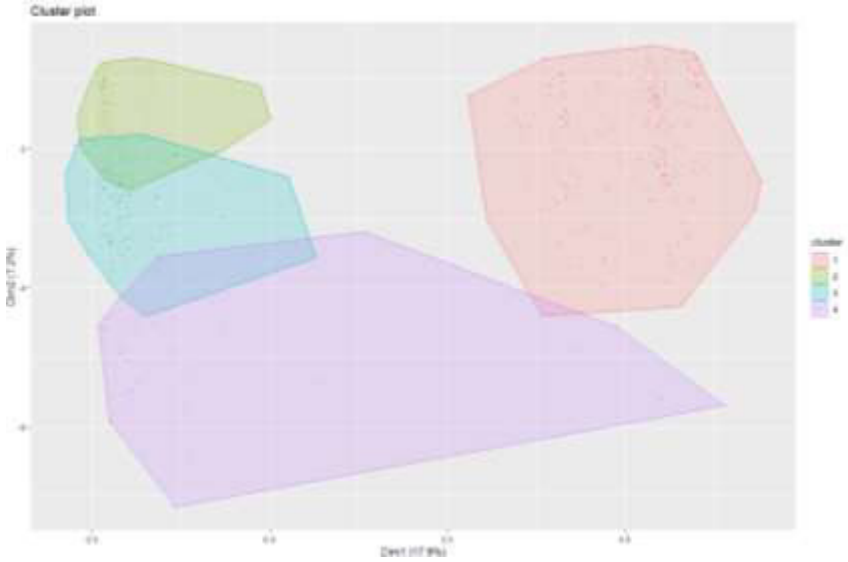

Figure 31- Clustering- Kmeans (PCA)

Figure 31 shows the result for clustering method in this study. Comparing with the previous results shown in figures 26 and 27, it is possible to see that this result is much cleaner, because there are less overlaps in the projection of the first two principal components, as it was the case before.

But are there word clusters with a larger fraction of contracts won by certain countries or not? We thus analyzed inside each cluster the distribution of ITTs per country, in percentage. The result is shown in table 10.

	AT	BE	CA	CH	CZ	DE	DK	EE	ES	FI	FR	GB	GR	IRL	IT	LU	LV	NL	NO	PL	PT	RO	RUS	SE	US
1	21.7	35.6	28.6	31.2	37.5	29.4	22.2	0	32.6	25.0	22.4	27.0	27.3	25	31.3	42.9	100	22.9	37.5	16.7	18.8	27.3	100	14.3	0
2	39.1	39.0	42.9	34.4	50.0	44.9	44.4	0	37.0	45.8	56.1	45.9	45.5	50	39.8	42.9	0	62.9	50.0	66.7	56.2	36.4	0	42.9	0
3	39.1	20.3	14.3	34.4	12.5	21.3	22.2	0	26.1	25.0	17.3	24.3	18.2	25	22.9	14.3	0	11.4	12.5	16.7	18.8	36.4	0	23.8	0
4	0.0	5.1	14.3	0.0	0.0	4.4	11.1	0	4.3	4.2	4.1	2.7	9.1	0	6.0	0.0	0	2.9	0.0	0.0	6.2	0.0	0	19.0	0

Table 10 – Distribution of winner countries per cluster

Analyzing figure 31 and table 10, it is possible to infer the following important

- Austria, Switzerland, Czech Republic, Estonia, Ireland, Latvia, Norway, Poland, Romenia, Russia and US have no ITT's awarded in cluster 4. Probably, they do not have any similarity with ITT's abstract inside this cluster.
- Five countries with more awarded ITTs have similarities in all the defined clusters.
- Germany chance of winning is bigger in cluster 2 than in clusters 1,3 and 4.
- The Netherlands, France, Poland and Portugal have more than 55% awarded ITT in cluster 2. This fact means that these countries have more chance of winning inside this cluster than in the others. Another point that we can infer is that these countries has more efforts and expertise's in ITTs fields from cluster 2.
- Cluster 2 presents the smallest distance between ITTs, meaning that the similarity between ITTs abstract is the largest, comparing to the other defined clusters. This fact can be inferred based on the axis X and Y.
- Cluster 4 has the largest distance between ITTs among the 4 defined clusters. This means that similarity between ITTs abstract is smaller in comparison with the other defined clusters. This fact can be inferred based on the axis X and Y.
- Austria, Switzerland and Romenia have the same chance of winning in cluster 2 and 3. These countries present the same percentage in both clusters.
- Cluster 1 includes the largest number of countries, once 23 of 25 countries belong to this cluster.
- In cluster 4, Canada and Sweden are the countries with more chance of winning one ESA ITT.
- All countries have more chance of winning in cluster 2, except Estonia, Latvia, Russia and USA.

One question that naturally arises is if considering dimensionality reduction using PCA with more components can produce better results. But which dimension could be better than 10? To answer to this question, we analyzed how much each component contributes to the total information in the dataset. In order to do this analysis, the PCA was decomposed into the 60 variables, and it was possible to evaluate how much each variable contributed with information from the dataset. Table 11 presents the results.

	eigenvalue	variance.percent	cumulative.variance.percent
Dim.1	10.76332351	17.93887252	17.93887
Dim.2	4.30461828	7.17436380	25.11324
Dim.3	1.89764622	3.16274371	28.27598
Dim.4	1.70038101	2.83396834	31.10995
Dim.5	1.67001937	2.78336561	33.89331
Dim.6	1.54713208	2.57855347	36.47187
Dim.7	1.47647905	2.46079842	38.93267
Dim.8	1.36221011	2.27035019	41.20302
Dim.9	1.32317001	2.20528335	43.40830
Dim.10	1.25858318	2.09763864	45.50594
Dim.11	1.23297112	2.05495187	47.56089
Dim.12	1.19529119	1.99215198	49.55304
Dim.13	1.17250587	1.95417645	51.50722
Dim.14	1.14331722	1.90552870	53.41275
Dim.15	1.11834253	1.86390421	55.27665
Dim.16	1.09280663	1.82134439	57.09800
Dim.17	1.07322436	1.78870726	58.88670
Dim.18	1.05572937	1.75954895	60.64625
Dim.19	1.02468802	1.70781336	62.35407
Dim.20	1.00642246	1.67737077	64.03144
Dim.21	0.99426785	1.65711308	65.68855
Dim.22	0.97750863	1.62918106	67.31773
Dim.23	0.94156459	1.56927432	68.88700
Dim.24	0.89975503	1.49959171	70.38660
Dim.25	0.88539126	1.47565210	71.86225
Dim.26	0.88088568	1.46814280	73.33039
Dim.27	0.82863982	1.38106637	74.71146
Dim.28	0.81093151	1.35155251	76.06301
Dim.29	0.80313285	1.33855475	77.40156
Dim.30	0.77584897	1.29308162	78.69465
Dim.31	0.76424285	1.27373808	79.96838
Dim.32	0.74746957	1.24578262	81.21417
Dim.33	0.72887839	1.21479732	82.42896
Dim.34	0.70524131	1.17540219	83.60437
Dim.35	0.68763455	1.14605758	84.75042
Dim.36	0.66319708	1.10532847	85.85575
Dim.37	0.64574260	1.07623766	86.93199
Dim.38	0.63521903	1.05869839	87.99069
Dim.39	0.62213474	1.03689123	89.02758
Dim.40	0.61289827	1.02149711	90.04908
Dim.41	0.57333598	0.95555997	91.00464
Dim.42	0.53447609	0.89079349	91.89543
Dim.43	0.52473915	0.87456526	92.77000
Dim.44	0.51612196	0.86020326	93.63020
Dim.45	0.49582937	0.82638228	94.45658
Dim.46	0.48304328	0.80507213	95.26165
Dim.47	0.45473757	0.75789596	96.01955
Dim.48	0.43935959	0.73226598	96.75182
Dim.49	0.42560514	0.70934190	97.46116
Dim.50	0.34641297	0.57735495	98.03851
Dim.51	0.27038211	0.45063685	98.48915
Dim.52	0.19984780	0.33307967	98.82223
Dim.53	0.17492656	0.29154427	99.11377
Dim.54	0.15264156	0.25440259	99.36818
Dim.55	0.13763539	0.22939232	99.59757
Dim.56	0.08320977	0.13868294	99.73625
Dim.57	0.05263110	0.08771849	99.82397
Dim.58	0.05034491	0.08390818	99.90788
Dim.59	0.03313844	0.05523073	99.96311
Dim.60	0.02213507	0.03689179	100.00000

Table 11- Analysis for each component from PCA

Analyzing the cumulative variance, it is possible to conclude that 24 dimensions explain more than 70% of the dataset information. Our main goal is to verify if using a larger dimension produces better results for relating cluster of words to the chance of winning. We kept the same number of clusters from the first PCA plot result, k=4, and we used the same cluster validation method as before, the silhouette. The clusters found are shown in figure 32.

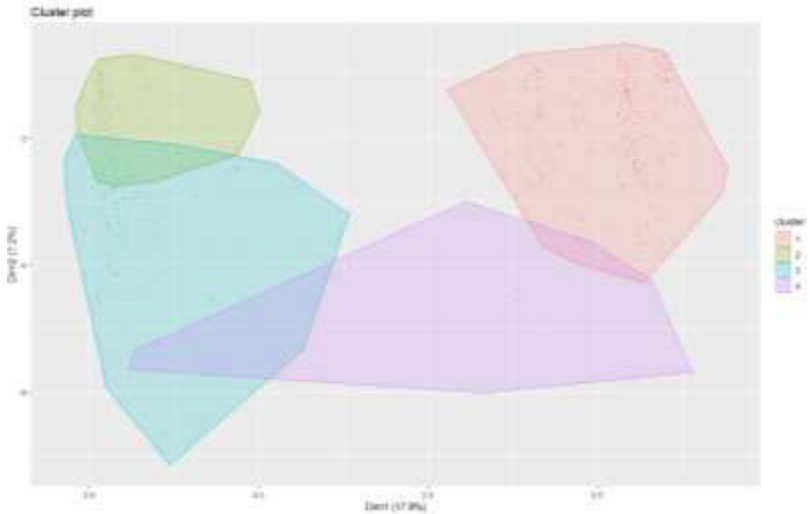

Figure 32- kmeans with 24 dimensions

The clusters plot is very similar to the clusters with 10 dimensions, but the countries distribution changed, as shown in table 12.

	AT	BE	CA	CH	CZ	DE	DK	EE	ES	FI	FR	GB	GR	HU	IT	LU	LV	NL	NO	PL	PT	RO	RUS	SE	US
1	21.7	33.6	28.6	31.2	37.5	27.2	22.2	0	32.6	25.0	22.4	27.0	27.3	25	30.1	42.9	100	22.9	37.5	16.7	18.8	27.3	100	14.3	0
2	47.8	42.4	42.9	46.9	50.0	45.5	44.4	0	47.8	54.2	60.2	57.7	54.5	75	45.6	42.9	0	71.4	50.0	66.7	62.5	54.5	0	57.1	0
3	30.4	20.3	28.6	21.9	12.5	21.3	33.3	0	19.6	20.8	15.3	14.4	18.2	0	22.8	14.3	0	5.7	12.5	16.7	18.8	18.2	0	19.0	0
4	0.0	1.7	0.0	0.0	0.0	2.9	0.0	0	0.0	0.0	2.0	0.9	0.0	0	1.2	0.0	0	0.0	0.0	0.0	0.0	0.0	0	9.5	0

Table 12- Countries distribution -PCA with 24 dimensions

From these results, it is possible to conclude that:

- With more dimensions the countries percentage changed.
- All the countries present more ITTs in cluster 2.
- Cluster 4 almost “disappeared”.

After these two exploratory analyses, the result was not completely satisfactory. Changing the PCA dimensions did not make possible to verify if there were cluster of words related to a chance of winning from one certain country. Probably, using different clusters parameters, as the number of clusters and validation parameter, or non-linear dimensionality reduction methods that could enable the adoption of a larger set of words, we could improve on the clustering results. It was conclusive, however, that the ESA ITT are agglomerated in clusters of words.
Other questions remain to be answered for a complete understanding of how cluster of words in ESA ITT define a chance of a country winning an ITT award. It is necessary to use different methods from those used in this study, and investigate cluster characteristics, as: How words are related with each other so that they form coherent ideas and concepts behind the ITTs?

CONCLUSION

From this study one conclusion can clearly be made: there are relations between ITT abstract words and a chance of certain country winning an ESA ITT.

The study started with the analysis of the relationship between countries that were awarded ESA ITTs, with ESA Offices and ESA Programs. From simple graphical analysis of matrices and correlations, and from further analysis of these results we saw that it seems to exist a relationship between number of employees dedicated to space sector, the countries organization to bid in ESA and the success in these bids. We also discovered a strong anti-correlation between the major European space player countries in ESA programs.

Then we employed text mining techniques to build document term matrices, the central data structure of this thesis. We developed a large set of R codes based on reference packages as TM, to perform the analysis. We developed logistic regression and stepwise models for each one of the 5 countries: Belgium, France, Great Britain (UK), Germany and Italy.

Simple logistic regression has more degrees of freedom than stepwise models, probably because of multicollinearity, thus it was natural to see that stepwise methods had better results than logistic regression. We selected the best models for each one of the 5 countries.

After that, we studied the prediction from these models, comparing the predicted value and what really happened. Using different methods, we concluded that, for more than 50% of the ITTs, the prediction works better than random. Also, the model prediction is 100% right, when the predicted value is bigger than 80%.

Considering the area under ROC the constructed models indicate that the probability of winning is higher than 50%. This means that the regression models are not random and in fact, certain words in ITTs abstracts have relation with the chance of certain country award an ITT. Cut-off points were defined for each country, showing the chance that a certain country must win an ITT without any model. The largest point was from Germany.

When some specific words appear in an ITT that can raise the chance of winning. This was explored trough the ODDs ratio analysis of the model variables in each of the 5 more awarded countries.

Then, we performed an exploratory analysis of how ITT abstracts clustered in the space defined by selected words, trying to find relationships between clusters and winning countries. Before any clustering, a correlation matrix was constructed, and a clustering tendency among the documents was detected. Then clusters were constructed using different hierarchical and non-hierarchical methods, all of them showing that the documents can be organized in clusters, although we could not find a correlation between the clusters and the ITT awarded country. This problem leaves the door open for further studies.

In the future, other questions should be answered for a better understanding of how words in ESA ITT abstract can predict what country will win an ITT, namely,

- How words relate to each other to form concepts within clusters?
- What ITTs can be considered "defining" for those clusters, if any?
- How those agglomerations can be associated to the countries winning each ITT?

These questions open new study possibilities as, for example, unexplored clustering methods, non-linear dimensionality reduction methods, text manipulation techniques and cluster validation.

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ANNEX

DEVELOPED MODEL FOR ALL COUNTRIES ("R RESULTS")

Germany – Developed Models and Area Under ROC curve

```
> summary(model_logistic_DE) # summary of logistic model for Germany

Call:
glm(formula = resVec_DE ~ ., family = binomial, data = m_t1)

Deviance Residuals:
   Min      1Q  Median      3Q     Max
-1.5303  -0.6859  -0.5369  -0.2977   2.4408

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.6083026  0.1995781  -8.059 7.72e-16 ***
aim          0.0895983  0.1467891   0.610  0.54161
applic      -0.1013428  0.1375350  -0.737  0.46121
capabl       0.1237862  0.1623258   0.763  0.44571
differ       0.1019318  0.1240789   0.822  0.41136
follow       0.2711489  0.1766084   1.535  0.12471
ground       0.2811396  0.1116534   2.518  0.01180 *
identifi     0.2481045  0.1621780   1.530  0.12606
integr       0.0675429  0.1290603   0.523  0.60074
part         0.1118275  0.1396563   0.801  0.42329
potenti     -0.2127593  0.1802934  -1.180  0.23797
propos      -0.2060894  0.1610986  -1.279  0.20080
specif      -0.2421509  0.1442248  -1.679  0.09316 .
time        -0.0463693  0.1845933  -0.251  0.80166
allow        0.0664308  0.1681415   0.395  0.69278
assess       0.0420730  0.1500536   0.280  0.77918
contractor  -0.0503053  0.1748446  -0.288  0.77357
european    -0.0450776  0.1331298  -0.339  0.73491
exist        0.0683644  0.1914850   0.357  0.72108
increas     -0.0456826  0.1964837  -0.233  0.81615
limit       -0.7643950  0.3003704  -2.545  0.01093 *
order        0.4022834  0.1692663   2.377  0.01747 *
power       -0.0169763  0.1029899  -0.165  0.86907
product      0.1595505  0.0992838   1.607  0.10805
result       0.1524122  0.1990737   0.766  0.44391
techniqu     0.0384960  0.1428249   0.270  0.78752
earth       -0.1198963  0.1359471  -0.882  0.37781
futur       -0.3510899  0.1773523  -1.980  0.04775 *
well        -0.1486133  0.1959347  -0.758  0.44816
within       0.2261312  0.2051738   1.102  0.27040
avail        0.1827054  0.1874631   0.975  0.32975
entiti       0.7108163  0.3492520   2.035  0.04183 *
generat     -0.4235633  0.2358631  -1.796  0.07253 .
improv      -0.1038298  0.1722144  -0.603  0.54657
one          0.0017409  0.1954456   0.009  0.99289
programm     0.1463704  0.2579264   0.567  0.57038
activiti     0.2057346  0.4985816   0.413  0.67987
activity    -0.2859238  0.2839058  -1.007  0.31388
concept      0.3177697  0.1108815   2.866  0.00416 **
emits       -0.0009751  0.3606952  -0.003  0.99784
full         0.4724942  0.2201307   2.146  0.03184 *
incl         1.1560522  0.7530430   1.535  0.12474
```

```
industrial  -0.6480449  1.6205696  -0.400  0.68924
news        -2.0276921  1.1653881  -1.740  0.08187 .
nonprimes    1.5636916  1.3810854   1.132  0.25754
pleas        0.0910301  0.3875052   0.235  0.81428
polici      -0.3659634  0.6739601  -0.543  0.58713
policy       0.2014990  0.9784931   0.206  0.83685
restrict     0.1141667  0.4717337   0.242  0.80877
nonprim     -0.8744894  0.8756684  -0.999  0.31796
term         0.2319096  0.1880167   1.233  0.21741
demonstr     0.0048615  0.1496350   0.032  0.97408
manufactur  -0.0251217  0.1224696  -0.205  0.83747
main        -0.2035419  0.2020711  -1.007  0.31380
particular  -0.1674443  0.2303660  -0.727  0.46731
spacecraft  -0.0910711  0.1273899  -0.715  0.47467
possibl     -0.2401661  0.1822895  -1.317  0.18767
select      -0.0799168  0.1859587  -0.430  0.66737
two         -0.1267851  0.1920082  -0.660  0.50905
analysi     -0.0447932  0.1575852  -0.284  0.77622
valid        0.0718330  0.1348328   0.533  0.59420
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 759.27  on 756  degrees of freedom
Residual deviance: 682.88  on 696  degrees of freedom
AIC: 804.88

Number of Fisher Scoring iterations: 5

> summary(mstep_DE) # summary of stepwise forward model for Germany

Call:
glm(formula = resVec_DE ~ concept + limit + order + futur + ground +
    full + product + generat, family = binomial, data = m_t1)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.6327  -0.6825  -0.6180  -0.3853   2.1871

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.55850    0.13373 -11.654  < 2e-16 ***
concept      0.29128    0.09564   3.046  0.00232 **
limit       -0.73729    0.26724  -2.759  0.00580 **
order        0.33995    0.13300   2.556  0.01059 *
futur       -0.32878    0.15429  -2.131  0.03309 *
ground       0.22004    0.09746   2.258  0.02395 *
full         0.38207    0.17421   2.193  0.02829 *
product      0.16883    0.08160   2.069  0.03855 *
generat     -0.27864    0.20318  -1.371  0.17026
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 759.27  on 756  degrees of freedom
Residual deviance: 715.80  on 748  degrees of freedom
AIC: 733.8
```

```
Number of Fisher Scoring iterations: 5

> summary(mstepb_DE) # summary of stepwise both model for Germany

Call:
glm(formula = resVec_DE ~ concept + limit + order + futur + ground +
    full + product + generat, family = binomial, data = m_t1)

Deviance Residuals:
   Min      1Q  Median      3Q     Max
-1.6327  -0.6825  -0.6180  -0.3853   2.1871

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.55850    0.13373 -11.654  < 2e-16 ***
concept      0.29128    0.09564   3.046  0.00232 **
limit       -0.73729    0.26724  -2.759  0.00580 **
order        0.33995    0.13300   2.556  0.01059 *
futur       -0.32878    0.15429  -2.131  0.03309 *
ground       0.22004    0.09746   2.258  0.02395 *
full         0.38207    0.17421   2.193  0.02829 *
product      0.16883    0.08160   2.069  0.03855 *
generat     -0.27864    0.20318  -1.371  0.17026
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 759.27  on 756  degrees of freedom
Residual deviance: 715.80  on 748  degrees of freedom
AIC: 733.8

Number of Fisher Scoring iterations: 5

> AIC(mstep_DE,mstepb_DE,mstepbw_DE)# shows AIC number from all stepwise models developed fo
r Germany

           df      AIC
mstep_DE    9 733.8035
mstepb_DE   9 733.8035
mstepbw_DE 12 732.1902
```

Area under roc curve

```
> (area_DE <- performance(pred_DE, "auc"))
An object of class "performance"
Slot "x.name":
[1] "None"

Slot "y.name":
[1] "Area under the ROC curve"

Slot "alpha.name":
[1] "none"

Slot "x.values":
list()

Slot "y.values":
[[1]]
```

[1] 0.656492

Slot "alpha.values":
list()

Belgium – Developed Models and Area under ROC curve

> summary(model_logistic_BE) # summary of logistic model for Belgium

Call:
glm(formula = resVec_BE ~ ., family = binomial, data = m_t1)

Deviance Residuals:
   Min   1Q Median   3Q   Max
-1.2849 -0.4914 -0.3638 -0.2129   2.5279

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -2.071336   0.261214 -7.930 2.2e-15 ***
aim   0.336544   0.187159   1.798   0.0722 .
applic   -0.020679   0.192770 -0.107   0.9146
capabl   0.306545   0.209590   1.463   0.1436
differ   0.181107   0.167951   1.078   0.2809
follow   0.003997   0.264130   0.015   0.9879
ground   -0.242294   0.194510 -1.246   0.2129
identifi   -0.161657   0.264791 -0.611   0.5415
integr   0.196683   0.159549   1.233   0.2177
part   -0.006673   0.205576 -0.032   0.9741
potenti   0.095254   0.238320   0.400   0.6894
propos   -0.181411   0.274080 -0.662   0.5080
specif   0.136998   0.206509   0.663   0.5071
time   -0.084787   0.297224 -0.285   0.7754
allow   0.055970   0.267313   0.209   0.8342
assess   -0.456231   0.302885 -1.506   0.1320
contractor   0.283906   0.164073   1.730   0.0836 .
european   0.142759   0.162592   0.878   0.3799
exist   -0.124214   0.301210 -0.412   0.6801
increas   0.066401   0.280338   0.237   0.8128
limit   -0.424241   0.441994 -0.960   0.3371
order   -0.122711   0.271130 -0.453   0.6508
power   -0.133637   0.170826 -0.782   0.4340
product   0.091601   0.135369   0.677   0.4986
result   -0.390632   0.372219 -1.049   0.2940
techniqu   0.113674   0.199383   0.570   0.5686
earth   0.065338   0.175995   0.371   0.7105
futur   0.036794   0.205358   0.179   0.8578
well   0.125882   0.267978   0.470   0.6385
within   -0.297386   0.324753 -0.916   0.3598
avail   -0.165837   0.337799 -0.491   0.6235
entiti   -0.648820   0.688718 -0.942   0.3462
generat   -0.393946   0.344634 -1.143   0.2530
improv   -0.576049   0.314618 -1.831   0.0671 .
one   0.118880   0.286049   0.416   0.6777
programm   0.194503   0.300247   0.648   0.5171
activiti   0.677451   0.648917   1.044   0.2965
activity   0.286859   0.347162   0.826   0.4086
concept   -0.155584   0.244040 -0.638   0.5238
emits   0.522745   0.533520   0.980   0.3272
full   -0.065384   0.346282 -0.189   0.8502

```
incl        -13.790198 684.686935  -0.020   0.9839
industrial    0.640004   1.698279   0.377   0.7063
news         -2.199005   1.484948  -1.481   0.1386
nonprimes     0.173259   1.762160   0.098   0.9217
pleas         0.256990   0.519608   0.495   0.6209
polici        1.077036   0.611192   1.762   0.0780 .
policy        0.083285   1.494623   0.056   0.9556
restrict     -0.653939   0.791581  -0.826   0.4087
nonprim      12.956272 684.687061   0.019   0.9849
term         -0.321365   0.364230  -0.882   0.3776
demonstr      0.232603   0.194464   1.196   0.2316
manufactur    0.035931   0.190367   0.189   0.8503
main         -0.207637   0.298727  -0.695   0.4870
particular    0.010145   0.326385   0.031   0.9752
spacecraft   -0.002068   0.200292  -0.010   0.9918
possibl       0.013928   0.267414   0.052   0.9585
select       -0.260903   0.287239  -0.908   0.3637
two           0.414372   0.240093   1.726   0.0844 .
analysi      -0.466930   0.311736  -1.498   0.1342
valid        -0.123570   0.220685  -0.560   0.5755
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 471.19  on 756  degrees of freedom
Residual deviance: 419.40  on 696  degrees of freedom
AIC: 541.4

Number of Fisher Scoring iterations: 15

> summary(mstep_BE) # summary of stepwise forward model for Belgium

Call:
glm(formula = resVec_BE ~ limit + assess + aim + generat + capabl +
    improv + analysi + contractor + incl + polici, family = binomial,
    data = m_t1)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.2016  -0.4869  -0.4075  -0.2919   2.5807

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)  -2.0726     0.1897 -10.928   <2e-16 ***
limit        -0.6203     0.4064  -1.526   0.1269
assess       -0.4415     0.2796  -1.579   0.1144
aim           0.2928     0.1568   1.868   0.0618 .
generat      -0.3740     0.3090  -1.210   0.2261
capabl        0.3356     0.1802   1.862   0.0626 .
improv       -0.4234     0.2831  -1.495   0.1348
analysi      -0.4521     0.2840  -1.592   0.1114
contractor    0.2848     0.1377   2.068   0.0386 *
incl         -1.1482     0.4843  -2.371   0.0178 *
polici        0.6149     0.3826   1.607   0.1080
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)
```

```
    Null deviance: 471.19  on 756  degrees of freedom
Residual deviance: 442.52  on 746  degrees of freedom
AIC: 464.52

Number of Fisher Scoring iterations: 6
```

```
> summary(mstepb_BE) # summary of stepwise both model for Belgium
```

```
Call:
glm(formula = resVec_BE ~ limit + assess + aim + capabl + improv +
    analysi + contractor + incl + polici, family = binomial,
    data = m_t1)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.2165  -0.4795  -0.4256  -0.2937   2.5566

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -2.1049     0.1875 -11.225   <2e-16 ***
limit        -0.6655     0.4059  -1.639   0.1011
assess       -0.4145     0.2755  -1.504   0.1325
aim           0.2444     0.1507   1.622   0.1047
capabl        0.3277     0.1736   1.888   0.0591 .
improv       -0.4269     0.2813  -1.518   0.1291
analysi      -0.5085     0.2808  -1.811   0.0701 .
contractor    0.2961     0.1378   2.149   0.0316 *
incl         -1.1806     0.4859  -2.430   0.0151 *
polici        0.6335     0.3834   1.652   0.0985 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 471.19  on 756  degrees of freedom
Residual deviance: 444.28  on 747  degrees of freedom
AIC: 464.28

Number of Fisher Scoring iterations: 6
```

```
> summary(mstepbw_BE)# summary of stepwise backward model for Belgium
```

```
Call:
glm(formula = resVec_BE ~ aim + capabl + assess + contractor +
    limit + improv + incl + polici + analysi, family = binomial,
    data = m_t1)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.2165  -0.4795  -0.4256  -0.2937   2.5566

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -2.1049     0.1875 -11.225   <2e-16 ***
aim           0.2444     0.1507   1.622   0.1047
capabl        0.3277     0.1736   1.888   0.0591 .
assess       -0.4145     0.2755  -1.504   0.1325
contractor    0.2961     0.1378   2.149   0.0316 *
```

```
limit       -0.6655     0.4059  -1.639   0.1011
improv      -0.4269     0.2813  -1.518   0.1291
incl        -1.1806     0.4859  -2.430   0.0151 *
polici       0.6335     0.3834   1.652   0.0985 .
analysi     -0.5085     0.2808  -1.811   0.0701 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 471.19  on 756  degrees of freedom
Residual deviance: 444.28  on 747  degrees of freedom
AIC: 464.28

Number of Fisher Scoring iterations: 6
```

> AIC(mstep_BE,mstepb_BE,mstepbw_BE)# shows AIC number from all stepwise models developed for Belgium

```
           df      AIC
mstep_BE   11 464.5180
mstepb_BE  10 464.2837
mstepbw_BE 10 464.2837
```

Area under ROC curve

> (area_BE <- performance(pred_BE, "auc"))

```
An object of class "performance"
Slot "x.name":
[1] "None"

Slot "y.name":
[1] "Area under the ROC curve"

Slot "alpha.name":
[1] "none"

Slot "x.values":
list()

Slot "y.values":
[[1]]
[1] 0.6729561


Slot "alpha.values":
list()
```

Italy- Developed models and Area under ROC curve

> summary(model_logistic_IT) # summary of logistic model for Italy

```
Call:
glm(formula = resVec_IT ~ ., family = binomial, data = m_t1)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.4036  -0.5741  -0.4203  -0.2059   2.7874

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)  -1.58413    0.21813  -7.262  3.8e-13 ***
```

aim	0.10094	0.17842	0.566	0.57158	
applic	-0.15576	0.18506	-0.842	0.39996	
capabl	0.25729	0.18089	1.422	0.15492	
differ	0.01053	0.14504	0.073	0.94213	
follow	-0.38349	0.27122	-1.414	0.15738	
ground	0.18918	0.12847	1.473	0.14086	
identifi	-0.18149	0.20352	-0.892	0.37253	
integr	-0.47972	0.22760	-2.108	0.03506	*
part	-0.35514	0.25780	-1.378	0.16833	
potenti	0.06966	0.19774	0.352	0.72463	
propos	0.14735	0.17471	0.843	0.39898	
specif	-0.08324	0.20004	-0.416	0.67732	
time	-0.04358	0.22798	-0.191	0.84839	
allow	0.17440	0.18469	0.944	0.34503	
assess	-0.49817	0.23692	-2.103	0.03549	*
contractor	-0.14690	0.27948	-0.526	0.59914	
european	0.48600	0.15459	3.144	0.00167	**
exist	-0.26186	0.24502	-1.069	0.28520	
increas	-0.08213	0.23701	-0.347	0.72895	
limit	-0.07134	0.26110	-0.273	0.78466	
order	0.19315	0.20634	0.936	0.34925	
power	0.09304	0.09892	0.941	0.34695	
product	-0.13303	0.13412	-0.992	0.32127	
result	0.24337	0.23367	1.041	0.29765	
techniqu	0.32094	0.12580	2.551	0.01073	*
earth	0.36625	0.13473	2.718	0.00656	**
futur	0.17536	0.16885	1.039	0.29903	
well	-0.50356	0.24781	-2.032	0.04215	*
within	-0.15449	0.25371	-0.609	0.54257	
avail	0.02127	0.24523	0.087	0.93090	
entiti	0.15252	0.48692	0.313	0.75410	
generat	0.02090	0.21817	0.096	0.92368	
improv	-0.04536	0.17830	-0.254	0.79917	
one	-0.33293	0.25907	-1.285	0.19876	
programm	-0.73611	0.45854	-1.605	0.10842	
activiti	-0.04755	0.66535	-0.071	0.94302	
activity	-0.53787	0.36505	-1.473	0.14064	
concept	-0.06447	0.16280	-0.396	0.69211	
emits	2.14487	1.18721	1.807	0.07082	.
full	0.01922	0.26912	0.071	0.94307	
incl	-0.80441	1.26698	-0.635	0.52549	
industrial	-12.86060	622.69720	-0.021	0.98352	
news	-1.01846	1.53227	-0.665	0.50626	
nonprimes	14.58764	622.69921	0.023	0.98131	
pleas	-0.18176	0.49177	-0.370	0.71168	
polici	-1.10533	1.41952	-0.779	0.43618	
policy	-1.98866	0.92864	-2.141	0.03223	*
restrict	0.25988	0.58037	0.448	0.65430	
nonprim	0.76130	1.43912	0.529	0.59680	
term	0.40039	0.19694	2.033	0.04205	*
demonstr	-0.14066	0.18358	-0.766	0.44354	
manufactur	-0.50670	0.27296	-1.856	0.06341	.
main	0.45382	0.20971	2.164	0.03046	*
particular	-0.12663	0.29012	-0.436	0.66250	
spacecraft	-0.05929	0.14817	-0.400	0.68903	
possibl	0.25482	0.18853	1.352	0.17650	
select	-0.11661	0.22916	-0.509	0.61086	
two	0.10406	0.21783	0.478	0.63285	
analysi	0.17148	0.16640	1.031	0.30277	
valid	-0.14931	0.18057	-0.827	0.40831	

```
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 634.58  on 756  degrees of freedom
Residual deviance: 525.85  on 696  degrees of freedom
AIC: 647.85

Number of Fisher Scoring iterations: 15
```

```
> summary(mstep_IT)# summary of stepwise forward model for Italy
```

```
Call:
glm(formula = resVec_IT ~ policy + emits + european + integr +
    manufactur + techniqu + earth + part + main + assess + term +
    well + allow + activity + programm + follow, family = binomial,
    data = m_t1)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.3998  -0.6040  -0.4502  -0.2502   2.9770

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)  -1.6089     0.1698  -9.478  < 2e-16 ***
policy       -2.0035     0.6326  -3.167  0.00154 **
emits         1.6877     0.5800   2.910  0.00361 **
european      0.4217     0.1336   3.157  0.00159 **
integr       -0.4242     0.2241  -1.893  0.05841 .
manufactur   -0.5517     0.2709  -2.037  0.04168 *
techniqu      0.2929     0.1150   2.548  0.01084 *
earth         0.3197     0.1109   2.883  0.00394 **
part         -0.3314     0.2233  -1.484  0.13771
main          0.4647     0.1901   2.444  0.01451 *
assess       -0.3551     0.2016  -1.761  0.07826 .
term          0.4474     0.1739   2.573  0.01009 *
well         -0.4934     0.2292  -2.153  0.03133 *
allow         0.2792     0.1563   1.786  0.07408 .
activity     -0.5489     0.3096  -1.773  0.07623 .
programm     -0.6062     0.3827  -1.584  0.11317
follow       -0.3276     0.2291  -1.430  0.15284
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 634.58  on 756  degrees of freedom
Residual deviance: 550.32  on 740  degrees of freedom
AIC: 584.32

Number of Fisher Scoring iterations: 6
```

```
> summary(mstepb_IT)# summary of stepwise both model for Italy
```

```
Call:
glm(formula = resVec_IT ~ policy + emits + european + integr +
    manufactur + techniqu + earth + part + main + assess + term +
    well + allow + activity + programm + follow, family = binomial,
    data = m_t1)
```

```
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.3998  -0.6040  -0.4502  -0.2502   2.9770

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)  -1.6089     0.1698  -9.478  < 2e-16 ***
policy       -2.0035     0.6326  -3.167  0.00154 **
emits         1.6877     0.5800   2.910  0.00361 **
european      0.4217     0.1336   3.157  0.00159 **
integr       -0.4242     0.2241  -1.893  0.05841 .
manufactur   -0.5517     0.2709  -2.037  0.04168 *
techniqu      0.2929     0.1150   2.548  0.01084 *
earth         0.3197     0.1109   2.883  0.00394 **
part         -0.3314     0.2233  -1.484  0.13771
main          0.4647     0.1901   2.444  0.01451 *
assess       -0.3551     0.2016  -1.761  0.07826 .
term          0.4474     0.1739   2.573  0.01009 *
well         -0.4934     0.2292  -2.153  0.03133 *
allow         0.2792     0.1563   1.786  0.07408 .
activity     -0.5489     0.3096  -1.773  0.07623 .
programm     -0.6062     0.3827  -1.584  0.11317
follow       -0.3276     0.2291  -1.430  0.15284
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 634.58  on 756  degrees of freedom
Residual deviance: 550.32  on 740  degrees of freedom
AIC: 584.32

Number of Fisher Scoring iterations: 6

> summary(mstepbw_IT)# summary of stepwise backward model for Italy

Call:
glm(formula = resVec_IT ~ follow + ground + integr + part + assess +
    european + techniqu + earth + well + programm + activity +
    emits + policy + term + manufactur + main, family = binomial,
    data = m_t1)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.4596  -0.6038  -0.4430  -0.2500   3.0044

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)  -1.5924     0.1683  -9.462  < 2e-16 ***
follow       -0.3610     0.2313  -1.561  0.11853
ground        0.1718     0.1115   1.540  0.12344
integr       -0.4400     0.2223  -1.979  0.04780 *
part         -0.3480     0.2220  -1.568  0.11699
assess       -0.3782     0.2059  -1.836  0.06631 .
european      0.4177     0.1370   3.049  0.00230 **
techniqu      0.3165     0.1140   2.777  0.00548 **
earth         0.2985     0.1104   2.703  0.00688 **
well         -0.5148     0.2286  -2.252  0.02430 *
programm     -0.5951     0.3771  -1.578  0.11453
```

```
activity     -0.5368     0.3099  -1.732  0.08320 .
emits         1.6521     0.5372   3.075  0.00210 **
policy       -1.9068     0.5999  -3.178  0.00148 **
term          0.4586     0.1735   2.644  0.00820 **
manufactur   -0.5472     0.2725  -2.008  0.04467 *
main          0.4773     0.1883   2.534  0.01127 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 634.58  on 756  degrees of freedom
Residual deviance: 551.07  on 740  degrees of freedom
AIC: 585.07

Number of Fisher Scoring iterations: 6


> AIC(mstep_IT,mstepb_IT,mstepbw_IT)# shows AIC number from all stepwise models developed for It
aly
           df      AIC
mstep_IT   17 584.3204
mstepb_IT  17 584.3204
mstepbw_IT 17 585.0713
```

Area under ROC curve

```
> (area_IT <- performance(pred_IT, "auc"))
An object of class "performance"
Slot "x.name":
[1] "None"

Slot "y.name":
[1] "Area under the ROC curve"

Slot "alpha.name":
[1] "none"

Slot "x.values":
list()

Slot "y.values":
[[1]]
[1] 0.7255399


Slot "alpha.values":
list()
```

France- Developed models

```
> summary(model_logistic_FR) # summary of logistic model for France

Call:
glm(formula = resVec_FR ~ ., family = binomial, data = m_t1)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.1511  -0.5840  -0.4010  -0.2338   2.5844

Coefficients:
```

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-1.759275	0.216071	-8.142	3.88e-16	***
aim	0.332686	0.159266	2.089	0.0367	*
applic	-0.146102	0.164515	-0.888	0.3745	
capabl	-0.153621	0.224846	-0.683	0.4945	
differ	-0.155344	0.162199	-0.958	0.3382	
follow	-0.003958	0.221087	-0.018	0.9857	
ground	-0.290680	0.166268	-1.748	0.0804	.
identifi	-0.062857	0.176669	-0.356	0.7220	
integr	-0.013377	0.150785	-0.089	0.9293	
part	0.281253	0.147808	1.903	0.0571	.
potenti	0.295071	0.177598	1.661	0.0966	.
propos	0.185056	0.173201	1.068	0.2853	
specif	-0.053527	0.179386	-0.298	0.7654	
time	0.111470	0.198054	0.563	0.5736	
allow	-0.373146	0.244116	-1.529	0.1264	
assess	0.386785	0.152946	2.529	0.0114	*
contractor	0.190325	0.149563	1.273	0.2032	
european	0.292303	0.137286	2.129	0.0332	*
exist	0.246963	0.197797	1.249	0.2118	
increas	-0.016043	0.226939	-0.071	0.9436	
limit	0.119528	0.217384	0.550	0.5824	
order	0.149501	0.199814	0.748	0.4543	
power	-0.121265	0.126375	-0.960	0.3373	
product	0.009531	0.113080	0.084	0.9328	
result	0.366836	0.205634	1.784	0.0744	.
techniqu	-0.560669	0.252867	-2.217	0.0266	*
earth	0.065332	0.138830	0.471	0.6379	
futur	0.207735	0.154605	1.344	0.1791	
well	0.166872	0.198971	0.839	0.4017	
within	-0.276469	0.256634	-1.077	0.2814	
avail	-0.198896	0.248470	-0.800	0.4234	
entiti	0.393808	0.372799	1.056	0.2908	
generat	-0.179912	0.234884	-0.766	0.4437	
improv	0.179199	0.175833	1.019	0.3081	
one	0.157931	0.219489	0.720	0.4718	
programm	-0.366699	0.370113	-0.991	0.3218	
activiti	-1.509309	0.694254	-2.174	0.0297	*
activity	-0.077892	0.321448	-0.242	0.8085	
concept	-0.052712	0.157488	-0.335	0.7378	
emits	-0.162866	0.496835	-0.328	0.7431	
full	-0.364358	0.312399	-1.166	0.2435	
incl	-2.291317	1.361860	-1.682	0.0925	.
industrial	2.289544	1.366348	1.676	0.0938	.
news	1.486493	1.076610	1.381	0.1674	
nonprimes	-1.259544	0.950927	-1.325	0.1853	
pleas	-0.853118	0.541826	-1.575	0.1154	
polici	-0.124641	0.605954	-0.206	0.8370	
policy	0.397528	1.322968	0.300	0.7638	
restrict	0.215257	0.502806	0.428	0.6686	
nonprim	1.160271	1.414610	0.820	0.4121	
term	-0.180843	0.234328	-0.772	0.4403	
demonstr	-0.237812	0.178893	-1.329	0.1837	
manufactur	-0.246898	0.182297	-1.354	0.1756	
main	-0.397569	0.236691	-1.680	0.0930	.
particular	-0.366685	0.290374	-1.263	0.2067	
spacecraft	0.275647	0.122301	2.254	0.0242	*
possibl	0.196566	0.204103	0.963	0.3355	
select	-0.180838	0.202053	-0.895	0.3708	
two	-0.465409	0.244353	-1.905	0.0568	.

```
analysi      0.024735   0.163999   0.151   0.8801
valid       -0.010244   0.160616  -0.064   0.9491
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 655.22  on 756  degrees of freedom
Residual deviance: 545.71  on 696  degrees of freedom
AIC: 667.71

Number of Fisher Scoring iterations: 6
```

```
> summary(mstep_FR)# summary of stepwise forward model for France

Call:
glm(formula = resVec_FR ~ assess + techniqu + part + full + aim +
    european + two + spacecraft + manufactur + allow + exist +
    ground + main + result + demonstr, family = binomial, data = m_t1)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.9771  -0.5950  -0.4709  -0.2943   2.7470

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)  -1.7961     0.1646 -10.913  < 2e-16 ***
assess        0.4372     0.1184   3.693 0.000222 ***
techniqu     -0.5498     0.2345  -2.345 0.019024 *
part          0.2760     0.1257   2.196 0.028066 *
full         -0.5871     0.2811  -2.089 0.036747 *
aim           0.3435     0.1322   2.599 0.009361 **
european      0.3107     0.1121   2.772 0.005575 **
two          -0.4466     0.2150  -2.077 0.037802 *
spacecraft    0.2660     0.1089   2.443 0.014574 *
manufactur   -0.2731     0.1534  -1.780 0.075041 .
allow        -0.3473     0.2167  -1.602 0.109089
exist         0.3042     0.1767   1.722 0.085077 .
ground       -0.2322     0.1477  -1.573 0.115818
main         -0.3443     0.2119  -1.625 0.104180
result        0.3196     0.1821   1.755 0.079229 .
demonstr     -0.2200     0.1554  -1.416 0.156769
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 655.22  on 756  degrees of freedom
Residual deviance: 582.17  on 741  degrees of freedom
AIC: 614.17

Number of Fisher Scoring iterations: 6

> summary(mstepb_FR)# summary of stepwise both model for France

Call:
glm(formula = resVec_FR ~ assess + techniqu + part + full + aim +
    european + two + spacecraft + manufactur + allow + exist +
    ground + main + result + demonstr, family = binomial, data = m_t1)
```

```
Deviance Residuals:
   Min      1Q  Median      3Q     Max
-1.9771  -0.5950  -0.4709  -0.2943   2.7470

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -1.7961     0.1646 -10.913  < 2e-16 ***
assess        0.4372     0.1184   3.693 0.000222 ***
techniqu     -0.5498     0.2345  -2.345 0.019024 *
part          0.2760     0.1257   2.196 0.028066 *
full         -0.5871     0.2811  -2.089 0.036747 *
aim           0.3435     0.1322   2.599 0.009361 **
european      0.3107     0.1121   2.772 0.005575 **
two          -0.4466     0.2150  -2.077 0.037802 *
spacecraft    0.2660     0.1089   2.443 0.014574 *
manufactur   -0.2731     0.1534  -1.780 0.075041 .
allow        -0.3473     0.2167  -1.602 0.109089
exist         0.3042     0.1767   1.722 0.085077 .
ground       -0.2322     0.1477  -1.573 0.115818
main         -0.3443     0.2119  -1.625 0.104180
result        0.3196     0.1821   1.755 0.079229 .
demonstr     -0.2200     0.1554  -1.416 0.156769
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 655.22  on 756  degrees of freedom
Residual deviance: 582.17  on 741  degrees of freedom
AIC: 614.17

Number of Fisher Scoring iterations: 6

> summary(mstepbw_FR)# summary of stepwise backward model for France

Call:
glm(formula = resVec_FR ~ aim + ground + part + allow + assess +
    european + exist + result + techniqu + activiti + incl +
    industrial + pleas + demonstr + manufactur + main + spacecraft +
    two, family = binomial, data = m_t1)

Deviance Residuals:
   Min      1Q  Median      3Q     Max
-2.1583  -0.6014  -0.4342  -0.2834   2.6706

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -1.7587     0.1781  -9.877  < 2e-16 ***
aim           0.3127     0.1326   2.358 0.018395 *
ground       -0.2323     0.1484  -1.565 0.117511
part          0.2639     0.1276   2.068 0.038602 *
allow        -0.3212     0.2202  -1.458 0.144783
assess        0.4302     0.1220   3.526 0.000423 ***
european      0.3092     0.1121   2.758 0.005811 **
exist         0.2644     0.1783   1.483 0.137990
result        0.3176     0.1833   1.733 0.083152 .
techniqu     -0.5177     0.2353  -2.200 0.027795 *
activiti     -0.9067     0.4446  -2.039 0.041436 *
incl         -0.8856     0.4793  -1.848 0.064643 .
industrial    2.3319     0.6534   3.569 0.000359 ***
```

```
pleas        -0.9618     0.4472  -2.151 0.031479 *
demonstr     -0.2422     0.1573  -1.540 0.123646
manufactur   -0.3203     0.1593  -2.011 0.044338 *
main         -0.3049     0.2112  -1.443 0.148916
spacecraft    0.2046     0.1123   1.821 0.068544 .
two          -0.4636     0.2140  -2.166 0.030305 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 655.22  on 756  degrees of freedom
Residual deviance: 572.30  on 738  degrees of freedom
AIC: 610.3

Number of Fisher Scoring iterations: 6
```

```
> AIC(mstep_FR,mstepb_FR,mstepbw_FR)# shows AIC number from all stepwise models developed for France
           df      AIC
mstep_FR   16 614.1712
mstepb_FR  16 614.1712
mstepbw_FR 19 610.2985
```

```
> (area_FR <- performance(pred_FR, "auc"))
An object of class "performance"
Slot "x.name":
[1] "None"

Slot "y.name":
[1] "Area under the ROC curve"

Slot "alpha.name":
[1] "none"

Slot "x.values":
list()

Slot "y.values":
[[1]]
[1] 0.727368


Slot "alpha.values":
list()
```

Great Britain- Developed models

```
> summary(model_logistic_GB) # summary of logistic model for Great Britain

Call:
glm(formula = resVec_GB ~ ., family = binomial, data = m_t1)

Deviance Residuals:
   Min      1Q  Median      3Q     Max
-1.6018  -0.6117  -0.4613  -0.3214   2.6243

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -2.0146386  0.2138602  -9.420  < 2e-16 ***
```

```
aim          0.3195060  0.1516655   2.107 0.035148 *
applic       0.0800398  0.1374893   0.582 0.560463
capabl      -0.0508887  0.1915244  -0.266 0.790468
differ      -0.0884291  0.1389309  -0.636 0.524453
follow      -0.0778397  0.2109585  -0.369 0.712142
ground       0.0602640  0.1269625   0.475 0.635029
identifi     0.0043402  0.1735826   0.025 0.980052
integr      -0.3305143  0.1854792  -1.782 0.074758 .
part        -0.2229712  0.1830215  -1.218 0.223118
potenti     -0.0820306  0.1789005  -0.459 0.646574
propos      -0.1547384  0.1768970  -0.875 0.381717
specif       0.1728250  0.1440879   1.199 0.230356
time         0.0385097  0.1674024   0.230 0.818058
allow       -0.1357472  0.2028519  -0.669 0.503372
assess       0.2112324  0.1377538   1.533 0.125176
contractor   0.1932514  0.1558163   1.240 0.214882
european    -0.1268027  0.1619462  -0.783 0.433632
exist       -0.0006249  0.1958527  -0.003 0.997454
increas      0.0551127  0.1902495   0.290 0.772056
limit        0.1706558  0.1939700   0.880 0.378965
order       -0.0838436  0.1945170  -0.431 0.666443
power        0.0660682  0.0954072   0.692 0.488632
product      0.0897450  0.1005972   0.892 0.372327
result       0.2741221  0.1965728   1.395 0.163165
techniqu    -0.0015158  0.1265007  -0.012 0.990440
earth        0.1521490  0.1239909   1.227 0.219786
futur        0.1561569  0.1505466   1.037 0.299612
well         0.0338325  0.1823402   0.186 0.852801
within       0.1409171  0.2156372   0.653 0.513440
avail       -0.2156828  0.2144964  -1.006 0.314641
entiti       0.0786221  0.3870931   0.203 0.839050
generat      0.2028126  0.1775406   1.142 0.253311
improv       0.0127651  0.1605996   0.079 0.936648
one          0.2448646  0.2004393   1.222 0.221844
programm     0.2669168  0.2471328   1.080 0.280118
activiti     0.9197726  0.4661224   1.973 0.048468 *
activity     0.8372611  0.2529354   3.310 0.000932 ***
concept      0.0489267  0.1225874   0.399 0.689807
emits        0.0281481  0.4581911   0.061 0.951014
full        -0.5455029  0.3269683  -1.668 0.095243 .
incl         0.4758701  0.7534218   0.632 0.527641
industrial   2.1950278  1.2132352   1.809 0.070414 .
news        -0.1626192  0.8136629  -0.200 0.841590
nonprimes   -1.6741251  0.8122799  -2.061 0.039301 *
pleas       -0.8915060  0.5267084  -1.693 0.090532 .
polici      -0.2966032  0.8006959  -0.370 0.711061
policy      -0.4851774  0.8589055  -0.565 0.572156
restrict    -0.5549854  0.4932464  -1.125 0.260518
nonprim     -0.0826833  0.9057533  -0.091 0.927265
term         0.0337307  0.2063606   0.163 0.870160
demonstr     0.0495233  0.1544338   0.321 0.748455
manufactur   0.0794517  0.1191446   0.667 0.504867
main        -0.3901159  0.2287073  -1.706 0.088056 .
particular  -0.1984805  0.2400047  -0.827 0.408245
spacecraft  -0.0199531  0.1342807  -0.149 0.881875
possibl     -0.1228061  0.2031115  -0.605 0.545429
select       0.0687893  0.1702267   0.404 0.686136
two          0.0496825  0.2053401   0.242 0.808817
analysi     -0.0631288  0.1682547  -0.375 0.707513
valid        0.0429513  0.1471030   0.292 0.770301
```

```
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 668.57  on 756  degrees of freedom
Residual deviance: 597.23  on 696  degrees of freedom
AIC: 719.23

Number of Fisher Scoring iterations: 5
```

```
> summary(mstep_GB)#summary of stepwise forward model for Great Britain

Call:
glm(formula = resVec_GB ~ aim + full + activity + integr + earth +
    main + assess + result + one, family = binomial, data = m_t1)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.3519  -0.6050  -0.5309  -0.3847   2.5388

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -1.8881     0.1536 -12.290  < 2e-16 ***
aim           0.3671     0.1279   2.870  0.00411 **
full         -0.8639     0.2865  -3.016  0.00256 **
activity      0.6574     0.2166   3.035  0.00240 **
integr       -0.2688     0.1576  -1.706  0.08810 .
earth         0.2152     0.1073   2.006  0.04487 *
main         -0.4299     0.2070  -2.077  0.03782 *
assess        0.1855     0.1114   1.665  0.09591 .
result        0.2829     0.1730   1.635  0.10198
one           0.2692     0.1784   1.509  0.13125
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 668.57  on 756  degrees of freedom
Residual deviance: 627.00  on 747  degrees of freedom
AIC: 647

Number of Fisher Scoring iterations: 5
```

```
> summary(mstepb_GB)# summary of stepwise both model for Great Britain

Call:
glm(formula = resVec_GB ~ aim + full + activity + integr + earth +
    main + assess + result + one, family = binomial, data = m_t1)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.3519  -0.6050  -0.5309  -0.3847   2.5388

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -1.8881     0.1536 -12.290  < 2e-16 ***
aim           0.3671     0.1279   2.870  0.00411 **
full         -0.8639     0.2865  -3.016  0.00256 **
```

```
activity     0.6574     0.2166   3.035  0.00240 **
integr      -0.2688     0.1576  -1.706  0.08810 .
earth        0.2152     0.1073   2.006  0.04487 *
main        -0.4299     0.2070  -2.077  0.03782 *
assess       0.1855     0.1114   1.665  0.09591 .
result       0.2829     0.1730   1.635  0.10198
one          0.2692     0.1784   1.509  0.13125
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 668.57  on 756  degrees of freedom
Residual deviance: 627.00  on 747  degrees of freedom
AIC: 647

Number of Fisher Scoring iterations: 5
```

```
> summary(mstepbw_GB)# summary of stepwise backward model for Great Britain

Call:
glm(formula = resVec_GB ~ aim + integr + assess + result + earth +
    activiti + activity + full + industrial + nonprimes + pleas +
    main, family = binomial, data = m_t1)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.4066  -0.5987  -0.5256  -0.3748   2.5143

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)  -1.8526     0.1659 -11.164  < 2e-16 ***
aim           0.3622     0.1283   2.823 0.004756 **
integr       -0.2683     0.1661  -1.616 0.106171
assess        0.1924     0.1124   1.711 0.087018 .
result        0.2816     0.1730   1.628 0.103551
earth         0.2084     0.1083   1.923 0.054470 .
activiti      0.6633     0.3576   1.855 0.063654 .
activity      0.7464     0.2252   3.314 0.000921 ***
full         -0.5633     0.3117  -1.807 0.070746 .
industrial    1.7019     0.7904   2.153 0.031307 *
nonprimes    -1.6878     0.6784  -2.488 0.012846 *
pleas        -0.7347     0.4690  -1.567 0.117208
main         -0.3840     0.2060  -1.864 0.062268 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 668.57  on 756  degrees of freedom
Residual deviance: 618.12  on 744  degrees of freedom
AIC: 644.12

Number of Fisher Scoring iterations: 5
```

```
> AIC(mstep_GB,mstepb_GB,mstepbw_GB) # shows AIC number for all developed models for Great Br
itain
           df      AIC
mstep_GB   10 647.0014
mstepb_GB  10 647.0014
```

mstepbw_GB 13 644.1195

Area under ROC curve

```
> (area_GB <- performance(pred_GB, "auc"))
An object of class "performance"
Slot "x.name":
[1] "None"

Slot "y.name":
[1] "Area under the ROC curve"

Slot "alpha.name":
[1] "none"

Slot "x.values":
list()

Slot "y.values":
[[1]]
[1] 0.6569059


Slot "alpha.values":
list()
```

First graphics- R code

```
require(XLConnect) # package for interface with excel
require(stringr) # package for manipulation of characters, whitespace, length

# Read the data file
Winners_ESA_initial <- readWorksheetFromFile("data_ESA_2018.xlsx", sheet=1, startRow =
1, endCol = 17)

# Extract the bidding country names from the winner field of the XLS file
Countries.itt <-
regmatches(Winners_ESA_initial$Winners,gregexpr("(?<=\\().*?(?=\\))",Winners_ESA_initial$
Winners, perl=TRUE))
Countries.itt <- as.matrix(Countries.itt)

# Prepare the vector with names of the bidding countries
Country_Names <- unique(unlist(Countries.itt))
Country_Names <- Country_Names[order(Country_Names)]
Country_Names <- as.matrix(Country_Names)

# Prepare the vector with names of the ESA Offices
ESA_Office_Per_ITT <- Winners_ESA_initial$ESA.Site
ESA_Office <- unique(Winners_ESA_initial$ESA.Site)
ESA_Office <- ESA_Office[order(ESA_Office)]

# Create the counter matrix that will store the number of contracts by country and office
numberOfCountries  <- length(unique(Country_Names))
numberOfEsaOffices <- length(unique(ESA_Office))
CounterMatrix <- matrix(rep(0, times=(numberOfCountries*numberOfEsaOffices)),
nrow=numberOfEsaOffices, ncol=numberOfCountries)

# Now, ITT by ITT, fill the counter matrix adding +1 for each ITT at the position of
# the country and ESA office that participated in the contract
# There are faster ways to do this, but lets keep it simple and understandable
for(i in 1:nrow(Winners_ESA_initial)) {
 # Extract the winner countries (can be more than one) and ESA offices (can be more than one)
 ITT_winnerCountry     <- unlist( Countries.itt[i] )
 ITT_contractEsaOffice <- unlist( ESA_Office_Per_ITT[i] )

 # Add one to the counter matrix at the position of the country and ESA office
 for(idxCountry in 1:length(ITT_winnerCountry)) {
  for(idxEsaOffice in 1:length(ITT_contractEsaOffice)) {
   CounterMatrixCol <- which(Country_Names == ITT_winnerCountry[idxCountry])
   CounterMatrixRow <- which(ESA_Office    == ITT_contractEsaOffice[idxEsaOffice])
   CounterMatrix[CounterMatrixRow, CounterMatrixCol] <-
CounterMatrix[CounterMatrixRow, CounterMatrixCol] + 1
  }
 }
}

# Normalization
Total_per_Country    <- apply(CounterMatrix, 2,sum)
Total_per_ESA_Office <- apply(CounterMatrix, 1,sum)
N_Countries <- apply(CounterMatrix, 1, function(x){x/Total_per_Country})
N_Office    <- apply(CounterMatrix, 2, function(x){x/Total_per_ESA_Office})
```

```
# Creates the image plot for the normalization by country
pdf("Distribution_norm_Country.pdf",width=16, height=8)
Norm_Countries_plot_colours <- image((N_Countries),col=terrain.colors(100),yaxt = "n",xaxt
= "n")
axis(1,at=seq(0,1,length.out = length(Country_Names)), labels= Country_Names, lty=0)
axis(2,at=seq(0,1,length.out = length(ESA_Office)), labels=ESA_Office, lty=0)
dev.off()

# Creates the image plot for the normalization by ESA Office
pdf("Distribution_norm_Office.pdf",width=16, height=8)
Norm_Offices_plot_colours <- image(t(N_Office),col=terrain.colors(100),yaxt = "n",xaxt =
"n")
axis(1,at=seq(0,1,length.out = length(Country_Names)), labels= Country_Names,lty=0)
axis(2,at=seq(0,1,length.out = length(ESA_Office)), labels=ESA_Office,lty=0)
dev.off()

# Prepare the vector with names of the ESA Programme Names
ESA_Program_Per_ITT <- Winners_ESA_initial$PROGRAMME.NAME
ESA_Program <- unique(Winners_ESA_initial$PROGRAMME.NAME)
ESA_Program <- ESA_Program[order(ESA_Program)]

# Create the counter matrix that will store the number of contracts by country, office and
Programme Names
numberOfCountries  <- length(unique(Country_Names))
numberOfEsaOffices <- length(unique(ESA_Office))
numberOfEsaProgram <- length(unique(ESA_Program))
CounterMatrix <- matrix(rep(0, times=(numberOfCountries*numberOfEsaProgram)),
nrow=numberOfEsaProgram, ncol=numberOfCountries)


# Now, ITT by ITT, fill the counter matrix adding +1 for each ITT at the position of
# the country and Program that participated in the contract
# There are faster ways to do this, but lets keep it simple and understandable
for(i in 1:nrow(Winners_ESA_initial)) {
  # Extract the winner countries (can be more than one), and ESA Programme (can be more than
one)
  ITT_winnerCountry     <- unlist( Countries.itt[i] )
  ITT_EsaProgramme <- unlist( ESA_Program_Per_ITT[i] )

  # Add one to the counter matrix at the position of the country and Esa Programme
  for(idxCountry in 1:length(ITT_winnerCountry)) {
    for(idxEsaProgramme in 1:length(ITT_EsaProgramme)) {
      CounterMatrixCol <- which(Country_Names == ITT_winnerCountry[idxCountry])
      CounterMatrixRow <- which(ESA_Program    == ITT_EsaProgramme[idxEsaProgramme])
      CounterMatrix[CounterMatrixRow, CounterMatrixCol] <-
CounterMatrix[CounterMatrixRow, CounterMatrixCol] + 1

    }
  }
}

# Normalization
Total_per_Country<- apply(CounterMatrix, 2,sum)
Total_per_ESA_Program <- apply(CounterMatrix, 1,sum)
```

```
N_Countries <- apply(CounterMatrix, 1, function(x){x/Total_per_Country})
N_Program <- apply(CounterMatrix, 2, function(x){x/Total_per_ESA_Program})


# Creates the image plot for the normalization by Country and Program
pdf("Distribution_norm_Country_per_Program.pdf", width= 14, height= 14)
Norm_Countries_plot_colours <- image(t(N_Program),col=terrain.colors(32),yaxt = "n",xaxt =
"n")
axis(1,at=seq(0,1,length.out = length(Country_Names)), labels= Country_Names, lty=0)
axis(2,at=seq(0,1,length.out = length(ESA_Program)), labels=(ESA_Program), lty=0)
dev.off()
```

Most frequent words – R code

```
require(XLConnect) # package for interface with excel
require(stringr) # package for manipulation of characters, whitespace, length
require(stringi) # package for manipulation of characters, whitespace, length
require(ggplot2) # package for graphic manipulation and development
require (stats) # package for statistics calculation and random number generation
require(tabplot)
require(aod)
require(gtools)
require(corrgram)
require(ROCR)
require(dplyr)
require(broom)
require(Hmisc)
require(rio)
require(tm) # package for text mining
require(MASS) # permit stepwise in a logistic model
require(WriteXLS) # export data from R to excel
require(SnowballC)
require(pRoc) # create ROC curve
require(arules) # create discret variables
require(Hmisc)
require(corrplot)


# Read the data file
Winners_ESA_initial <- readWorksheetFromFile("data_ESA_2018.xlsx", sheet=1, startRow = 1,
endCol = 16)

# Extract the bidding country names from the winner field of the XLS file
Countries.itt <-
regmatches(Winners_ESA_initial$Winners,gregexpr("(?<=\\().*?(?=\\))",Winners_ESA_initial$
Winners, perl=TRUE))
Countries.itt <- as.matrix(Countries.itt)

# Prepare the vector with names of the bidding countries
Country_Names <- unique(unlist(Countries.itt))
Country_Names <- Country_Names[order(Country_Names)]
Country_Names <- as.matrix(Country_Names)

# Prepare the vector with program names
ESA_Program_Per_ITT <- Winners_ESA_initial$PROGRAMME.NAME
ESA_Program <- unique(Winners_ESA_initial$PROGRAMME.NAME)
ESA_Program <- ESA_Program[order(ESA_Program)]

#Prepare vector with ESA Offices
ESA_Offices <- unique(unlist(Winners_ESA_initial$ESA.Site))
ESA_Offices <- ESA_Offices[order(ESA_Offices)]
ESA_Offices <- as.matrix(ESA_Offices)

Matrix_Office_Countries.itt<-cbind(Countries.itt,Winners_ESA_initial) # data base with
countries of the ITT winner countries
```

```
Programs_ESA<-c(Matrix_Office_Countries.itt$PROGRAMME.NAME) # create a vector with the ESA program name
Offices<-c(Matrix_Office_Countries.itt$ESA.Site) # creat a new matrix with the information of the countries

# Extract the bidding country names from the winner field of the XLS file
Countries.itt <- regmatches(Winners_ESA_initial$Winners,gregexpr("(?<=\\().*?(?=\\))",Winners_ESA_initial$Winners, perl=TRUE))
Countries.itt <- as.matrix(Countries.itt)

# Prepare the vector with names of the bidding countries
Country_Names <- unique(unlist(Countries.itt))
Country_Names <- Country_Names[order(Country_Names)]
Country_Names <- as.matrix(Country_Names)

# Prepare the vector with names of the ESA Offices
ESA_Office_Per_ITT <- Winners_ESA_initial$ESA.Site
ESA_Office <- unique(Winners_ESA_initial$ESA.Site)
ESA_Office <- ESA_Office[order(ESA_Office)]

# Create the counter matrix that will store the number of contracts by country and office
numberOfCountries  <- length(unique(Country_Names))
numberOfEsaOffices <- length(unique(ESA_Office))
CounterMatrix <- matrix(rep(0, times=(numberOfCountries*numberOfEsaOffices)), nrow=numberOfEsaOffices, ncol=numberOfCountries)

Total_per_Country    <- apply(CounterMatrix, 2,sum)
Total_per_ESA_Office <- apply(CounterMatrix, 1,sum)

Total_ITT_awarded_per_country<-cbind(Country_Names,Total_per_Country)

text_final<- Matrix_Office_Countries.itt$ABSTRACT  #take the abstract from each ESA ITT
text_final<-stemDocument(text_final, language = "english") # mantain the root of each word
text_final<-tolower(text_final) #convert the text in lower case
stop_w<-stopwords("english")# create a vector with english stop words
text_final<-removeWords(text_final,stop_w)# remove stopword from english language
text_final<-removePunctuation(text_final) # remove punctuations
text_final<-removeNumbers(text_final) # remove numbers
text_final<-stripWhitespace(text_final) # remove extra white space
text_final<-wordStem(text_final,language= "english") #mantain the primitive form of the word, not considering verbal times, plural and singular
text_final<-c(text_final) # text_final as character
text_corpus<- Corpus(VectorSource(c(text_final))) # create a corpus for the DTM.
#The source for this DTM will be a vector extracted from the original database ( only abstract colum)

dtm <- TermDocumentMatrix(text_corpus)
# remove terms that occurs in 15% of the documents and mantain words that appears at least in 85% of the document
dtm<-removeSparseTerms(dtm,0.85)
m <- as.matrix(dtm) # declare DTM as matrix
m_t<-t(m) # transpose DTM matrix to allow manipulate it
m_t1=as.data.frame(m_t) # declare dtm transposed matrix as data frame
```

most_freq_words<-findFreqTerms(dtm, lowfreq = 300)# word that appears at least 300 times

Correlation Matrix, Regression models, prediction and ODD.Ratio – R code

```
require(XLConnect) # package for interface with excel
require(stringr) # package for manipulation of characters, whitespace, length
require(stringi) # package for manipulation of characters, whitespace, length
require(ggplot2) # package for graphic manipulation and development
require (stats) # package for statistics calculation and random number generation
require(tabplot)
require(aod)
require(gtools)
require(corrgram) # correlation matrix
require(ROCR) # create ROC curve
require(dplyr)# package with different types of manipulating tools
require(broom) #package for graphics formatting
require(Hmisc)
require(rio)
require(tm) # package for text mining
require(MASS) # permit stepwise in a logistic model
require(WriteXLS) # export data from R to excel
require(SnowballC)
require(pRoc) # create ROC curve
require(arules) # create discret variables
require(Hmisc)
require(corrplot)# package for correlation matrix


# Read the data file
Winners_ESA_initial <- readWorksheetFromFile("data_ESA_2018.xlsx", sheet=1, startRow =
1, endCol = 16)

# Extract the bidding country names from the winner field of the XLS file
Countries.itt <-
regmatches(Winners_ESA_initial$Winners,gregexpr("(?<=\\().*?(?=\\))",Winners_ESA_initial$
Winners, perl=TRUE))
Countries.itt <- as.matrix(Countries.itt)


# Prepare the vector with names of the bidding countries
Country_Names <- unique(unlist(Countries.itt))
Country_Names <- Country_Names[order(Country_Names)]
Country_Names <- as.matrix(Country_Names)


# Prepare the vector with program names
ESA_Program_Per_ITT <- Winners_ESA_initial$PROGRAMME.NAME
ESA_Program <- unique(Winners_ESA_initial$PROGRAMME.NAME)
ESA_Program <- ESA_Program[order(ESA_Program)]

#Prepare vector with ESA Offices
ESA_Offices <- unique(unlist(Winners_ESA_initial$ESA.Site))
ESA_Offices <- ESA_Offices[order(ESA_Offices)]
ESA_Offices <- as.matrix(ESA_Offices)
```

```
Matrix_Office_Countries.itt<-cbind(Countries.itt,Winners_ESA_initial) # data base with
countries of the ITT winner countries

# Create the counter matrix that will store the number of contracts by country,office and
Programme Names
numberOfCountries  <- length(unique(Country_Names))
numberOfEsaOffices <- length(unique(ESA_Offices))
numberOfEsaProgram <- length(unique(ESA_Program))
CounterMatrix <- matrix(rep(0, times=(numberOfCountries*numberOfEsaProgram)),
nrow=numberOfEsaProgram, ncol=numberOfCountries)


# Now, ITT by ITT, fill the counter matrix adding +1 for each ITT at the position of
# the country and Program that participated in the contract
# There are faster ways to do this, but lets keep it simple and understandable
for(i in 1:nrow(Matrix_Office_Countries.itt)) {
  # Extract the winner countries (can be more than one), and ESA Programme (can be more than
one)
  ITT_winnerCountry     <- unlist( Countries.itt[i] )
  ITT_EsaProgramme <-unlist( ESA_Program)

  # Add one to the counter matrix at the position of the country and Esa Programme
  for(idxCountry in 1:length(ITT_winnerCountry)) {
    for(idxEsaProgramme in 1:length(ITT_EsaProgramme)) {
      CounterMatrixCol <- which(Country_Names == ITT_winnerCountry[idxCountry])
      CounterMatrixRow <- which(ESA_Program    == ITT_EsaProgramme[idxEsaProgramme])
      CounterMatrix[CounterMatrixRow, CounterMatrixCol] <-
CounterMatrix[CounterMatrixRow, CounterMatrixCol] + 1

    }
  }
}

Programs_ESA<-c(Matrix_Office_Countries.itt$PROGRAMME.NAME) # create a vector with
the ESA program name
Offices<-c(Matrix_Office_Countries.itt$ESA.Site) # creat a new matrix with the information of
the countries

#SUM NUMBER OF AWARDED ITTS FROM BELGIUM
{
  resVec_BE <- vector(length=nrow(Countries.itt))
  for( i in 1:length(Countries.itt ) )
  {
    if (length(Countries.itt[[i]]) == 1)
    {
      if(Countries.itt[i] == "BE")  # write here the acronym for the country you want the number
of awarded ITT

      { resVec_BE[i] <- 1 }

    }
    else { for (j in 1:length(Countries.itt[[i]]))# keep the value 1, if is true that in one columm
appears the country we are studing
```

```
    { if(Countries.itt[[i]][j] == "BE") # write here the acronym for the country you want the
number of awarded ITT

    { resVec_BE[i] <- 1 } # keep the value 1, if is true that in one columm appears the country
we are studing

    }


    }
  }
  sum_BE<- sum (resVec_BE) # keep the somatory of ITT numbers from the country we are
studing

}

#SUM NUMBER OF AWARDED ITTS FROM GERMANY
{
  resVec_DE <- vector(length=nrow(Countries.itt))
  for( i in 1:length(Countries.itt ) )
  {
    if (length(Countries.itt[[i]]) == 1)
    {
      if(Countries.itt[i] == "DE")  # write here the acronym for the country you want the number
of awarded ITT

      { resVec_DE[i] <- 1 }

    }
    else { for (j in 1:length(Countries.itt[[i]]))# keep the value 1, if is true that in one columm
appears the country we are studing

    { if(Countries.itt[[i]][j] == "DE") # write here the acronym for the country you want the
number of awarded ITT

    { resVec_DE[i] <- 1 } # keep the value 1, if is true that in one columm appears the country
we are studing

    }


    }
  }
  sum_DE<- sum (resVec_DE) # keep the somatory of ITT numbers from the country we are
studing

}

#SUM AWARDED ITTS FROM FRANCE
{
  resVec_FR <- vector(length=nrow(Countries.itt))
  for( i in 1:length(Countries.itt ) )
  {
    if (length(Countries.itt[[i]]) == 1)
    {
```

```
     if(Countries.itt[i] == "FR")  # write here the acronym for the country you want the number
of awarded ITT

     { resVec_FR[i] <- 1 }

    }
   else { for (j in 1:length(Countries.itt[[i]]))# keep the value 1, if is true that in one columm
appears the country we are studing

   { if(Countries.itt[[i]][j] == "FR") # write here the acronym for the country you want the
number of awarded ITT

   { resVec_FR[i] <- 1 } # keep the value 1, if is true that in one columm appears the country we
are studing

    }


    }
  }
  sum_FR<- sum (resVec_FR) # keep the somatory of ITT numbers from the country we are
studing

}

#SUM AWARDED ITTS FROM GREAT BRITAIN
{
  resVec_GB <- vector(length=nrow(Countries.itt))
  for( i in 1:length(Countries.itt ) )
  {
    if (length(Countries.itt[[i]]) == 1)
    {
     if(Countries.itt[i] == "GB")  # write here the acronym for the country you want the number
of awarded ITT

     { resVec_GB[i] <- 1 }

    }
   else { for (j in 1:length(Countries.itt[[i]]))# keep the value 1, if is true that in one columm
appears the country we are studing

   { if(Countries.itt[[i]][j] == "GB") # write here the acronym for the country you want the
number of awarded ITT

   { resVec_GB[i] <- 1 } # keep the value 1, if is true that in one columm appears the country
we are studing

    }


    }
  }
  sum_GB<- sum (resVec_GB) # keep the somatory of ITT numbers from the country we are
studing
```

```
}

#SUM AWARDED ITTS FROM ITALY
{
 resVec_IT <- vector(length=nrow(Countries.itt))
 for( i in 1:length(Countries.itt ) )
 {
  if (length(Countries.itt[[i]]) == 1)
  {
   if(Countries.itt[i] == "IT")  # write here the acronym for the country you want the number of awarded ITT

    { resVec_IT[i] <- 1 }

  }
  else { for (j in 1:length(Countries.itt[[i]]))# keep the value 1, if is true that in one columm appears the country we are studing

  { if(Countries.itt[[i]][j] == "IT") # write here the acronym for the country you want the number of awarded ITT

  { resVec_IT[i] <- 1 } # keep the value 1, if is true that in one columm appears the country we are studing

  }


  }
 }
 sum_IT<- sum (resVec_IT) # keep the somatory of ITT numbers from the country we are studing

}

#SUM AWARDED ITTS FROM PORTUGAL
{
 resVec_PT <- vector(length=nrow(Countries.itt))
 for( i in 1:length(Countries.itt ) )
 {
  if (length(Countries.itt[[i]]) == 1)
  {
   if(Countries.itt[i] == "PT")  # write here the acronym for the country you want the number of awarded ITT

    { resVec_PT[i] <- 1 }

  }
  else { for (j in 1:length(Countries.itt[[i]]))# keep the value 1, if is true that in one columm appears the country we are studing

  { if(Countries.itt[[i]][j] == "PT") # write here the acronym for the country you want the number of awarded ITT

  { resVec_PT[i] <- 1 } # keep the value 1, if is true that in one columm appears the country we are studing
```

```
    }


    }
  }
  sum_PT<- sum (resVec_PT) # keep the somatory of ITT numbers from the country we are
studing

}

text_final<- Matrix_Office_Countries.itt$ABSTRACT  #take the abstract from each ESA ITT
text_final<-stemDocument(text_final, language = "english") # mantain the root of each word
text_final<-tolower(text_final) #convert the text in lower case
stop_w<-stopwords("english")# create a vector with english stop words
text_final<-removeWords(text_final,stop_w)# remove stopword from english language
stop_w_dtm<-
(c("activ","also","base","can","current","develop","esa","high","includ","level","new","oper","p
erform","process", "provid", "requir", "satellit", "servic", "shall",
"space","support","system","technolog",
"use","data","design","implement","studi","test","mission","procur","model","need","object","a
ddit","inform","measur","smes","will","phase"))
text_final<-removeWords(text_final,stop_w_dtm)
text_final<-removePunctuation(text_final) # remove punctuations
text_final<-removeNumbers(text_final) # remove numbers
text_final<-stripWhitespace(text_final) # remove extra white space
text_final<-wordStem(text_final,language= "english") #mantain the primitive form of the word,
not considering verbal times, plural and singular
text_final<-c(text_final) # text_final as character
text_corpus<- Corpus(VectorSource(c(text_final))) # create a corpus for the DTM.
#The source for this DTM will be a vector extracted from the original database ( only abstract
colum)

dtm <- TermDocumentMatrix(text_corpus)
# remove terms that occurs in 15% of the documents and mantain words that appears at least in
85% of the document
dtm<-removeSparseTerms(dtm,0.85)
m <- as.matrix(dtm) # declare DTM as matrix
m_t<-t(m) # transpose DTM matrix to allow manipulate it
m_t1=as.data.frame(m_t) # declare dtm transposed matrix as data frame

#Plot correlation matrix
correlation_matrix<- cor(t(m))
image(correlation_matrix,col=terrain.colors(32))
corrplot(correlation_matrix)

### Create logistic model and Stepwise models for Germany (DE)
m_t1$resVec_DE=resVec_DE # create a new matrix with the number of success of Germany ,
with the abstract of each itt
model_logistic_DE <- glm(resVec_DE~.,family=binomial,m_t1) # calculate logistic model for
Germany
m0_DE=glm(resVec_DE~1,family=binomial,m_t1)
summary(model_logistic_DE) # summary of logistic model for Germany
mstep_DE=stepAIC(m0_DE,list(upper = model_logistic_DE, lower = m0_DE),direction =
"forward")
```

```
summary(mstep_DE) # summary of stepwise forward model for Germany
mstepb_DE=stepAIC(m0_DE,list(upper = model_logistic_DE, lower = m0_DE),direction =
"both")
summary(mstepb_DE) # summary of stepwise both model for Germany
mstepbw_DE=stepAIC(model_logistic_DE,list(upper = model_logistic_DE, lower =
m0_DE),direction = "back")
summary(mstepbw_DE)# summary of Stepwise backward model for Germany)
AIC(mstep_DE,mstepb_DE,mstepbw_DE)# shows AIC number from all stepwise models
developed for Germany

#ROCR
library(ROCR)
fit_DE<-mstep_DE$fitted # extract fitted from Germany stepwise forward model
pred_DE <- prediction( fit_DE,m_t1$resVec_DE) # first parameter is the object which
prediction is desired and second is additional arguments affecting the prediction produced.

# Sensibility and Specificity
sensibility_DE <- performance(pred_DE,"tpr")
plot(sensibility_DE)
specificity_DE <- performance(pred_DE,"tnr")
plot(specificity_DE,add=T)

# Area under Roc Curve
(area_DE <- performance(pred_DE, "auc"))

#Roc curve plot
roc_DE <- performance(pred_DE,"tpr","fpr")
plot(roc_DE, t="l",lty=1,
    lwd=2,
    xlab="1-specificity", ylab="Sensibility DE", main= "ROC curve:
    itt awarded by DE")
abline(0,1, lty=2, lwd=2)


### Create logistic model for Belgium

m_t<-t(m) # transpose DTM matrix to allow manipulate it
m_t1=as.data.frame(m_t) # declare dtm transposed matrix as data frame
m_t1$resVec_BE=resVec_BE # create a new matrix with the number of success of Belgium ,
with the abstract of each itt

model_logistic_BE <- glm(resVec_BE~.,family=binomial,m_t1) # calculate logistic model for
Belgium
m0_BE=glm(resVec_BE~1,family=binomial,m_t1)
summary(model_logistic_BE) # summary of logistic model for Belgium
mstep_BE=stepAIC(m0_BE,list(upper = model_logistic_BE, lower = m0_BE),direction =
"forward")
summary(mstep_BE) # summary of stepwise forward model for Belgium
mstepb_BE=stepAIC(m0_BE,list(upper = model_logistic_BE, lower = m0_BE),direction =
"both")
summary(mstepb_BE) # summary of stepwise both model for Belgium
mstepbw_BE=stepAIC(model_logistic_BE,list(upper = model_logistic_BE, lower =
m0_BE),direction = "back")
summary(mstepbw_BE)# summary of stepwise backward model for Belgium
```

```
AIC(mstep_BE,mstepb_BE,mstepbw_BE)# shows AIC number from all stepwise models
developed for Belgium

#ROCR
library(ROCR)
fit_BE<-mstep_BE$fitted # extract fitted values from Belgium stepwise forward model
pred_BE <- prediction( fit_BE,m_t1$resVec_BE)# first parameter is the object which prediction
is desired and second is additional arguments affecting the prediction produced.

#Sensibility and Specificity
sensibility_BE <- performance(pred_BE,"tpr")
plot(sensibility_BE)
specificity_BE <- performance(pred_BE,"tnr")
plot(specificity_BE,add=T)

# Area under ROC curve
(area_BE <- performance(pred_BE, "auc"))

# roc curve plot
roc_BE <- performance(pred_BE,"tpr","fpr")
plot(roc_DE, t="l",lty=1,
    lwd=2,
    xlab="1-specificity", ylab="Sensibility BE", main= "ROC curve:
    itt awarded by BE")
abline(0,1, lty=2, lwd=2)

### Create logistic model for IT
m_t<-t(m) # transpose DTM matrix to allow manipulate it
m_t1=as.data.frame(m_t) # declare dtm transposed matrix as data frame
m_t1$resVec_IT=resVec_IT # create a new matrix with the number of success of Italy , with
the abstract of each itt

model_logistic_IT <- glm(resVec_IT~.,family=binomial,m_t1) # calculate logistic model for
Italy
m0_IT=glm(resVec_IT~1,family=binomial,m_t1)
summary(model_logistic_IT) # summary of logistic model for Italy
mstep_IT=stepAIC(m0_IT,list(upper = model_logistic_IT, lower = m0_IT),direction =
"forward")
summary(mstep_IT)# summary of stepwise forward model for Italy
mstepb_IT=stepAIC(m0_IT,list(upper = model_logistic_IT, lower = m0_IT),direction = "both")
summary(mstepb_IT)# summary of stepwise both model for Italy
mstepbw_IT=stepAIC(model_logistic_IT,list(upper = model_logistic_IT, lower =
m0_IT),direction = "back")
summary(mstepbw_IT)# summary of stepwise backward model for Italy
AIC(mstep_IT,mstepb_IT,mstepbw_IT)# shows AIC number from all stepwise models
developed for Italy

#ROCR
library(ROCR)
fit_IT<-mstep_IT$fitted# extract fitted values from Italy stepwise forward model
par(mfrow=c(1,1))
pred_IT <-prediction(fit_IT, m_t1$resVec_IT)# first parameter is the object which prediction is
desired and second is additional arguments affecting the prediction produced.

# roc curve
```

```
sensibility_IT <- performance(pred_IT,"tpr")
plot(sensibility_IT)
specificity_IT <- performance(pred_IT,"tnr")
plot(specificity_IT,add=T)
# Area sob a Curva ROC
(area_IT <- performance(pred_IT, "auc"))

# roc curve plot
roc_IT <- performance(pred_DE,"tpr","fpr") # roc curve
plot(roc_DE, t="l",lty=1,
    lwd=2,
    xlab="1-specificity", ylab="Sensibility IT", main= "ROC curve:
    itt awarded by IT")
abline(0,1, lty=2, lwd=2)

### Create logistic model for FR

m_t<-t(m) # transpose DTM matrix to allow manipulate it
m_t1=as.data.frame(m_t) # declare dtm transposed matrix as data frame
m_t1$resVec_FR=resVec_FR # create a new matrix with the number of success of Belgium ,
with the abstract of each itt

model_logistic_FR <- glm(resVec_FR~.,family=binomial,m_t1) # calculate logistic model for
France
m0_FR=glm(resVec_FR~1,family=binomial,m_t1)
summary(model_logistic_FR) # summary of logistic model for France
mstep_FR=stepAIC(m0_FR,list(upper = model_logistic_FR, lower = m0_FR),direction =
"forward")
summary(mstep_FR)# summary of stepwise forward model for France
mstepb_FR=stepAIC(m0_FR,list(upper = model_logistic_FR, lower = m0_FR),direction =
"both")
summary(mstepb_FR)# summary of stepwise both model for France
mstepbw_FR=stepAIC(model_logistic_FR,list(upper = model_logistic_FR, lower =
m0_FR),direction = "back")
summary(mstepbw_FR)# summary of stepwise backward model for France
AIC(mstep_FR,mstepb_FR,mstepbw_FR)# shows AIC number from all stepwise models
developed for France

#ROCR
library(ROCR)
fit_FR<-mstep_FR$fitted # extract fitted values from France stepwise forward model
par(mfrow=c(1,1))
pred_FR <- prediction( fit_FR,m_t1$resVec_FR) # first parameter is the object which
prediction is desired and second is additional arguments affecting the prediction produced.

# Sensibility and Specificity
sensibility_FR <- performance(pred_FR,"tpr")
plot(sensibility_FR)
specificity_FR <- performance(pred_FR,"tnr")
plot(specificity_FR,add=T)
# area under Roc Curve
(area_FR <- performance(pred_FR, "auc"))

# roc curve plot
roc_FR <- performance(pred_FR,"tpr","fpr")
```

```
plot(roc_FR, t="l",lty=1,
    lwd=2,
    xlab="1-specificity", ylab="Sensibility FR", main= "ROC curve:
    itt awarded by FR")
abline(0,1, lty=2, lwd=2)


### Create logistic model for GB

m_t<-t(m) # transpose DTM matrix to allow manipulate it
m_t1=as.data.frame(m_t) # declare dtm transposed matrix as data frame
m_t1$resVec_GB=resVec_GB # create a new matrix with the number of success of Great
Britain , with the abstract of each itt

model_logistic_GB <- glm(resVec_GB~.,family=binomial,m_t1) # calculate logistic model for
GB
m0_GB=glm(resVec_GB~1,family=binomial,m_t1)
summary(model_logistic_GB) # summary of logistic model for Great Britain
mstep_GB=stepAIC(m0_GB,list(upper = model_logistic_GB, lower = m0_GB),direction =
"forward")
summary(mstep_GB)# summary of stepwise forward model for Great Britain
mstepb_GB=stepAIC(m0_GB,list(upper = model_logistic_GB, lower = m0_GB),direction =
"both")
summary(mstepb_GB)# summary of stepwise both model for Great Britain
mstepbw_GB=stepAIC(model_logistic_GB,list(upper = model_logistic_GB, lower =
m0_GB),direction = "back")
summary(mstepbw_GB)# summary of stepwise backward model for Great Britain
AIC(mstep_GB,mstepb_GB,mstepbw_GB) # shows AIC number for all developed models for
Great Britain

#ROCR
library(ROCR)
fit_GB<-mstep_GB$fitted # extract fitted values from Great Britain stepwise forward model
pred_GB <- prediction( fit_GB,m_t1$resVec_GB)# first parameter is the object which
prediction is desired and second is additional arguments affecting the prediction produced.

# Sensibility and Specificity
sensibility_GB <- performance(pred_GB,"tpr")
plot(sensibility_GB)
specificity_GB <- performance(pred_GB,"tnr")
plot(specificity_GB,add=T)

# Area under Roc Curve
(area_GB <- performance(pred_GB, "auc"))

# roc curve plot
roc_GB <- performance(pred_GB,"tpr","fpr")
plot(roc_GB, t="l",lty=1,
    lwd=2,
    xlab="1-specificity", ylab="Sensibility GB", main= "ROC curve:
    itt awarded by GB")
abline(0,1, lty=2, lwd=2)


odd.ratio_BE= exp(coef(model_logistic_BE)) # ODD Ratio for Belgium
```

```
odd.ratio_DE= exp(coef(model_logistic_DE)) # ODD Ratio for Germany
odd.ratio_FR= exp(coef(model_logistic_FR)) # ODD Ratio for France
odd.ratio_GB= exp(coef(model_logistic_GB)) # ODD Ratio for Great Britain
odd.ratio_IT= exp(coef(model_logistic_IT)) # ODD Ratio for Italy



################################################################################
#####################################
# Export data for excel


fit_DE<-as.data.frame(fit_DE)
export(fit_DE, "file_DE.csv")

fit_BE<-as.data.frame(fit_BE)
export(fit_BE, "file_BE.csv")

fit_FR<-as.data.frame(fit_FR)
export(fit_FR, "file_FR.csv")

fit_IT<-as.data.frame(fit_IT)
export(fit_IT, "file_IT.csv")

fit_GB<-as.data.frame(fit_GB)
export(fit_GB, "file_GB.csv")

odd.ratio_IT<-as.data.frame(odd.ratio_IT)
export( odd.ratio_IT, "odd_IT.csv")

odd.ratio_DE<-as.data.frame(odd.ratio_DE)
export( odd.ratio_DE, "odd_DE.csv")

odd.ratio_BE<-as.data.frame(odd.ratio_BE)
export( odd.ratio_BE, "odd_BE.csv")

odd.ratio_FR<-as.data.frame(odd.ratio_FR)
export( odd.ratio_FR, "odd_FR.csv")

odd.ratio_GB<-as.data.frame(odd.ratio_GB)
export(odd.ratio_GB, "odd_GB.csv")
```

R code for clustering techniques

```
require(XLConnect) # package for interface with excel
require(stringr) # package for manipulation of characters, whitespace, length
require(stringi) # package for manipulation of characters, whitespace, length
require(ggplot2) # package for graphic manipulation and development
require (stats) # package for statistics calculation and random number generation
require(tabplot)
require(aod)
require(gtools)
require(corrgram)
require(ROCR)
require(dplyr)
require(broom)
require(Hmisc)
require(rio)
require(tm) # package for text mining
require(MASS) # permit stepwise in a logistic model
require(WriteXLS) # export data from R to excel
require(SnowballC)
require(pRoc) # create ROC curve
require(arules) # create discret variables
require(cluster)
require(dendextend)
require(factoextra)
require(mclust)
require(utils)
require(clValid)# cluster validation tools
require(ggfortify)
require(FactoMineR)
require(survival)
require(MASS)

# Read the data file
Winners_ESA_initial <- readWorksheetFromFile("data_ESA_2018.xlsx", sheet=1, startRow =
1, endCol = 16)

# Extract the bidding country names from the winner field of the XLS file
Countries.itt <-
regmatches(Winners_ESA_initial$Winners,gregexpr("(?<=\\().*?(?=\\))",Winners_ESA_initial$
Winners, perl=TRUE))
Countries.itt <- as.matrix(Countries.itt)

# Prepare the vector with names of the bidding countries
Country_Names <- unique(unlist(Countries.itt))
Country_Names <- Country_Names[order(Country_Names)]
Country_Names <- as.matrix(Country_Names)

# Prepare the vector with names of the ESA Offices
ESA_Office_Per_ITT <- Winners_ESA_initial$ESA.Site
ESA_Office <- unique(Winners_ESA_initial$ESA.Site)
ESA_Office <- ESA_Office[order(ESA_Office)]

# Create the counter matrix that will store the number of contracts by country and office
numberOfCountries  <- length(unique(Country_Names))
```

```
numberOfEsaOffices <- length(unique(ESA_Office))
CounterMatrix <- matrix(rep(0, times=(numberOfCountries*numberOfEsaOffices)),
nrow=numberOfEsaOffices, ncol=numberOfCountries)

# Now, ITT by ITT, fill the counter matrix adding +1 for each ITT at the position of
# the country and ESA office that participated in the contract
# There are faster ways to do this, but lets keep it simple and understandable
for(i in 1:nrow(Winners_ESA_initial)) {
  # Extract the winner countries (can be more than one) and ESA offices (can be more than one)
  ITT_winnerCountry     <- unlist( Countries.itt[i] )
  ITT_contractEsaOffice <- unlist( ESA_Office_Per_ITT[i] )

  # Add one to the counter matrix at the position of the country and ESA office
  for(idxCountry in 1:length(ITT_winnerCountry)) {
    for(idxEsaOffice in 1:length(ITT_contractEsaOffice)) {
      CounterMatrixCol <- which(Country_Names == ITT_winnerCountry[idxCountry])
      CounterMatrixRow <- which(ESA_Office    == ITT_contractEsaOffice[idxEsaOffice])
      CounterMatrix[CounterMatrixRow, CounterMatrixCol] <-
CounterMatrix[CounterMatrixRow, CounterMatrixCol] + 1
    }
  }
}

# Normalization
Total_per_Country    <- apply(CounterMatrix, 2,sum)
Total_per_ESA_Office <- apply(CounterMatrix, 1,sum)
N_Countries <- apply(CounterMatrix, 1, function(x){x/Total_per_Country})
N_Office    <- apply(CounterMatrix, 2, function(x){x/Total_per_ESA_Office})

# Creates the image plot for the normalization by country
pdf("Distribution_norm_Country.pdf",width=16, height=8)
Norm_Countries_plot_colours <- image((N_Countries),col=terrain.colors(100),yaxt = "n",xaxt
= "n")
axis(1,at=seq(0,1,length.out = length(Country_Names)), labels= Country_Names, lty=0)
axis(2,at=seq(0,1,length.out = length(ESA_Office)), labels=ESA_Office, lty=0)
dev.off()

# Creates the image plot for the normalization by ESA Office
pdf("Distribution_norm_Office.pdf",width=16, height=8)
Norm_Offices_plot_colours <- image(t(N_Office),col=terrain.colors(100),yaxt = "n",xaxt =
"n")
axis(1,at=seq(0,1,length.out = length(Country_Names)), labels= Country_Names,lty=0)
axis(2,at=seq(0,1,length.out = length(ESA_Office)), labels=ESA_Office,lty=0)
dev.off()

# Prepare the vector with names of the ESA Programme Names
ESA_Program_Per_ITT <- Winners_ESA_initial$PROGRAMME.NAME
ESA_Program <- unique(Winners_ESA_initial$PROGRAMME.NAME)
ESA_Program <- ESA_Program[order(ESA_Program)]

# Create the counter matrix that will store the number of contracts by country,office and
Programme Names
numberOfCountries  <- length(unique(Country_Names))
numberOfEsaOffices <- length(unique(ESA_Office))
numberOfEsaProgram <- length(unique(ESA_Program))
```

```
CounterMatrix <- matrix(rep(0, times=(numberOfCountries*numberOfEsaProgram)),
nrow=numberOfEsaProgram, ncol=numberOfCountries)


# Now, ITT by ITT, fill the counter matrix adding +1 for each ITT at the position of
# the country and Program that participated in the contract
# There are faster ways to do this, but lets keep it simple and understandable
for(i in 1:nrow(Winners_ESA_initial)) {
  # Extract the winner countries (can be more than one), and ESA Programme (can be more than
one)
  ITT_winnerCountry     <- unlist( Countries.itt[i] )
  ITT_EsaProgramme <- unlist( ESA_Program_Per_ITT[i] )

  # Add one to the counter matrix at the position of the country and Esa Programme
  for(idxCountry in 1:length(ITT_winnerCountry)) {
    for(idxEsaProgramme in 1:length(ITT_EsaProgramme)) {
      CounterMatrixCol <- which(Country_Names == ITT_winnerCountry[idxCountry])
      CounterMatrixRow <- which(ESA_Program    == ITT_EsaProgramme[idxEsaProgramme])
      CounterMatrix[CounterMatrixRow, CounterMatrixCol] <-
CounterMatrix[CounterMatrixRow, CounterMatrixCol] + 1

    }
  }
}

# Normalization
Total_per_Country<- apply(CounterMatrix, 2,sum)
Total_per_ESA_Program <- apply(CounterMatrix, 1,sum)
N_Countries <- apply(CounterMatrix, 1, function(x){x/Total_per_Country})
N_Program <- apply(CounterMatrix, 2, function(x){x/Total_per_ESA_Program})


# Creates the image plot for the normalization by Country and Program
pdf("Distribution_norm_Country_per_Program.pdf", width= 14, height= 14)
Norm_Countries_plot_colours <- image(t(N_Program),col=terrain.colors(32),yaxt = "n",xaxt =
"n")
axis(1,at=seq(0,1,length.out = length(Country_Names)), labels= Country_Names, lty=0)
axis(2,at=seq(0,1,length.out = length(ESA_Program)), labels=(ESA_Program), lty=0)
dev.off()

data_with_Countries<-cbind(Winners_ESA_initial,Countries.itt)
text_final<- data_with_Countries$ABSTRACT  #take the abstract from each ESA ITT

text_final<-stemDocument(text_final, language = "english") # mantain the root of each word
text_final<-tolower(text_final) #convert the text in lower case
stop_w<-stopwords("english")# create a vector with english stop words
text_final<-removeWords(text_final,stop_w)# remove stopword from english language
stop_w_dtm<-
(c("activ","also","base","can","current","develop","esa","high","includ","level","new","oper","p
erform","process", "provid", "requir", "satellit", "servic", "shall",
"space","support","system","technolog",
"use","data","design","implement","studi","test","mission","procur","model","need","object","a
ddit","inform","measur","smes","will","phase"))
text_final<-removeWords(text_final,stop_w_dtm)
text_final<-removePunctuation(text_final) # remove punctuations
```

```
text_final<-removeNumbers(text_final) # remove numbers
text_final<-stripWhitespace(text_final) # remove extra white space
text_final<-wordStem(text_final,language= "english") #mantain the primitive form of the word, not considering verbal times, plural and singular
text_final<-c(text_final) # text_final as character
text_corpus<- Corpus(VectorSource(c(text_final))) # create a corpus for the DTM.
#The source for this DTM will be a vector extracted from the original database ( only abstract colum)

dtm <- TermDocumentMatrix(text_corpus)
# remove terms that occurs in 15% of the documents and mantain words that appears at least in 85% of the document
dtm<-removeSparseTerms(dtm,0.85)
m <- as.matrix(dtm) # declare DTM as matrix
m_t<-t(m) #transporse matrix m
dim(m_t)
m_t[which(is.na(m_t), arr.ind=TRUE)] <- 0

#Cluster construction

plot(hclust(dist(m_t))) # compute cluster using complete method

# data preparation for correlation matrix
set.seed(123)
ss <- sample(1:757, 757) # Take 50 random rows, inside the 757 observations
df <- m_t[ss,] # Subset of the 50 random rows
df.scaled <- scale(df)

#Computing correlation based distances
dist.cor <- get_dist(df.scaled, method = "pearson")

#Visualizing correlation matrices from all 757 observations
fviz_dist(dist.cor)


# Agglomerative Nesting (Hierarchical Clustering)
agnes(m_t, metric = "euclidean", stand = FALSE, method = "average")

# Compute agnes()
res.agnes <- agnes(m_t, method = "complete")
# Agglomerative coefficient
res.agnes$ac

pltree(res.agnes, cex = 0.6, hang = -1,main = "Dendrogram of agnes")

# Compute diana()
res.diana <- diana(m_t, metric = "euclidean")
# Plot the tree
pltree(res.diana, cex = 0.6, hang = -1,main = "Dendrogram of diana")

# Divise coefficient; amount of clustering structure found
res.diana$dc


#define optimal cluster number
```

```
fviz_nbclust(df, kmeans, method = "silhouette", k.max = 30) + theme_classic() #optimal
clustering number for Kmeans
fviz_nbclust(df, pam, method = "silhouette", k.max = 20) + theme_classic() #optimal clustering
number for PAM

#non-hierarchical clustering
cluster_itt_Kmeans<-kmeans(m_t, centers=5);
cluster_itt_PAM<-pam(m_t, 4);
fviz_cluster(list(data = m_t, cluster =cluster_itt_Kmeans$cluster ))
fviz_cluster(list(data = m_t, cluster =cluster_itt_PAM$cluster ))



# select the best method of clustering among the used in this thesis without PCA
express <- m_t
intern <- clValid(express, 2:20, clMethods = c("hierarchical","kmeans", "diana", "pam"),
validation = "internal")
summary(intern)

#PCA clusters

m_t_PCA<-prcomp(m_t, scale=TRUE)# PCA construction

# Cluster number study, considering a certain number of dimensions
nDimToConsider <- 10
fviz_nbclust(x=m_t_PCA$x[,1:nDimToConsider], FUNcluster=kmeans, method = "silhouette",
k.max=25)

# Clustering solution
pp<-kmeans(m_t_PCA$x[,1:nDimToConsider], centers = 4)
fviz_cluster(list(data=m_t, cluster=as.factor(pp$cluster)), labelsize=6, geom="point",
pointsize=0.2, show.clust.cent=FALSE)

# Lets see if there are word clusters with a larger fraction of contracts won by
# certain countries or not...
countries_winner<-data_with_Countries$Countries.itt
countries_winner<-unlist(c(countries_winner)) # country winner as character
nClusts <- length(unique(pp$cluster))
totWinner <- table(unlist(countries_winner))
myClustWinnerMat <- matrix(nrow=nClusts, ncol=length(totWinner))
for(i in 1:nClusts){
  clNumb <- i
  clNumbWinner <- table( c(unlist(countries_winner[which(pp$cluster==clNumb)]),
unique(unlist(countries_winner)) )) - 1
  myClustWinnerMat[i,] <- clNumbWinner
}
myClustWinnerMat <- apply(myClustWinnerMat, 2, function(i) i/sum(i))
myClustWinnerMat[which(is.na(myClustWinnerMat), arr.ind=TRUE)] <- 0
colnames(myClustWinnerMat) <- names(clNumbWinner)
# Here is the matrix with showing the percentage of contracts won by each country (each
country adds to 100).
print(round(myClustWinnerMat,3)*100)
matrix_pca_cluster<-print(round(myClustWinnerMat,3)*100)
```

Answers from Space Agency and Space Offices, and ESA Procurement Department

Gmail by Google

Izabella Hemprich <izabella.hemprich@sim.ul.pt>

Information - Austrian Space activities

Michaela Gitsch <Michaela.Gitsch@ffg.at> 18 de outubro de 2018 às 10:32
Para: Hemprich Izabella <izabella.hemprich@sim.ul.pt>

Dear Izabelle Hemprich,

for more information about the Aeronautics and Space Agency of FFG
please go to
https://www.ffg.at/content/ihre-ansprechpartnerinnen-der-agentur-f-r-luft-und-raumfahrt

best regards,

Michaela Gitsch
Agentur für Luft- und Raumfahrt
Österreichische Forschungsförderungsgesellschaft mbH (FFG)
Sensengasse 1
A-1090 Wien

Tel +43 (0)5 7755-3302
Fax +43 (0)5 7755-97900
michaela.gitsch@ffg.at
www.ffg.at, www.ffg.at/alr

>>> Izabella Hemprich <izabella.hemprich@sim.ul.pt> 15.10.2018 14:20
[Citação ocultada]

Ihre AnsprechpartnerInnen in der Agentur für Luft- und Raumfahrt

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Tel +43 (0)5 7755-3001
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Stephan Mayer
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stephan.mayer@ffg.at

Telekommunikation / Erdbeobachtung

Luc Berset
Tel +43 (0)5 7755-3308
luc.berset@ffg.at

Thomas Geist
Tel +43 (0)5 7755-3310
thomas.geist@ffg.at

Weltraumwissenschaften, Bemannte Raumfahrt, Robotische Exploration, Weltraumtransportsysteme

Förderungen suchen

Ich suche (Thema)

Ich suche (Zielgruppe)

nationale Förderungen

internationale Förderungen

Förderung suchen

Projektdatenbank
Kurzinfos zu geförderten Projekten

eCall
Meine Projekte abwickeln und verwalten

Förderpilot
Bundes- und Landesförderungen auf einen Klick

Weitere Informationen

Agentur für Luft- und Raumfahrt der FFG

Andre Peter
Tel +43 (0)5 7755-3309
andre.peter@ffg.at

Österreichisches Weltraumprogramm ASAP

Ludwig Hofer
Tel + 43(0)5 7755-3301
ludwig.hofer@ffg.at

European Space Policy Institute (ESPI)

Wolfgang Würz
tel +43 (0)1 718 111-811
wolfgang.wuerz@espi.or.at

Gmail by Google

Izabella Hemprich <izabella.hemprich@sim.ul.pt>

RE: General information : Information Canada Space Agency

Info (ASC/CSA) <asc.info.csa@canada.ca> 24 de outubro de 2018 às 15:11
Para: "izabella.hemprich@sim.ul.pt" <izabella.hemprich@sim.ul.pt>

Good day,

Thank you for contacting the Canadian Space Agency (CSA).

Please note that the CSA has approximately 670 employees. You may visit our website for more information.

Best regards,

Service à la clientèle | Communications et affaires publiques

Agence spatiale canadienne | Gouvernement du Canada

asc.info.csa@canada.ca | Tél. : 450-926-4351

Customer Service | Communications and Public Affairs

Canadian Space Agency | Government of Canada

asc.info.csa@canada.ca | Tel. : 450-926-4351

From: asc.webmestre-webmaster.csa@canada.ca <asc.webmestre-webmaster.csa@canada.ca>
Sent: October-14-18 9:39 AM
To: Info (ASC/CSA) <asc.info.csa@canada.ca>
Subject: General information : Information Canada Space Agency

Canadian Space Agency

Information request form

General information

Information Canada Space Agency

Message
Dear Sir or Madam,

I´m a research engineer and now i´m finishing my master thesis in applied mathematics.
My tesis is a study regarding how ESA ITT´s is correlated with countries, expertises and other variables.
I´m studying all ITT´s since 2013.
Now, I´m studying how ESA awarded ITTs are correlated with the number of human resources that each space office has.
I want to ask you, if is it possible to provide me oficial information regarding the number of Canada Space Agency employees?
If you have any doubt, please feel free to contact me.

With best regards,

--
Izabella Hemprich
Control Engineer and Msc Student in Applied Mathematics
FCUL,CENTRA-SIM group

Date/Time

Sent on
Sunday, October 14, 2018 at 9:38

Communications

Canadian citizen
No

Further details
Yes

Send me a response
Yes

Contact info

Name
Izabella Hemprich

E-mail
izabella.hemprich@sim.ul.pt

email: izabella.hemprich@sim.ul.pt
skype: izabella_hemprich
phone: 351 217500000 - ext: 28136
FCUL web site: http://www.fc.ul.pt/
CENTRA-SIM web site: http://centra.tecnico.ulisboa.pt/network/sim/

Home phone
351-915-5289

Work phone
351-217-5000 #28136

Gmail by Google

Izabella Hemprich <izabella.hemprich@sim.ul.pt>

Information regarding Space business in Denmark

office <office@space.dtu.dk> 17 de outubro de 2018 às 15:35
Para: Izabella Hemprich <izabella.hemprich@sim.ul.pt>

Hi Izabella

At DTU Space (National Space Institute, Technical University of Denmark) we are 150 employees.

Kind regards,

Lene Bettenhaus

Ledelsessekretær

DTU Space

Danmarks Tekniske Universitet

Institut for Rumforskning og Rumteknologi

Elektrovej

Bygning 328, Rum 132

2800 Kgs. Lyngby

Direkte telefon 45259502

lene@space.dtu.dk

www.dtu.dk

Fra: Izabella Hemprich [mailto:izabella.hemprich@sim.ul.pt]
Sendt: 15. oktober 2018 15:30
Til: office
Emne: Re: Information regarding Space business in Denmark

[Citação ocultada]

Gmail by Google

Izabella Hemprich <izabella.hemprich@sim.ul.pt>

Information regarding Space business in Denmark

office <office@space.dtu.dk> 25 de outubro de 2018 às 14:06
Para: Izabella Hemprich <izabella.hemprich@sim.ul.pt>

Hi

No Denmark do not have an Space Agency.

We are under the Danish Government.

Danish Agency for Science and Higher Education: ufm@ufm.dk

Kind regards,

Lene Bettenhaus

Ledelsessekretær

DTU Space

Danmarks Tekniske Universitet

Institut for Rumforskning og Rumteknologi

Elektrovej

Bygning 328, Rum 132

2800 Kgs. Lyngby

Direkte telefon 45259502

lene@space.dtu.dk

www.dtu.dk

Fra: Izabella Hemprich [mailto:izabella.hemprich@sim.ul.pt]
Sendt: 23. oktober 2018 17:02
Til: office
Emne: Re: Information regarding Space business in Denmark

Dear Lene,

Thank you again for answering my question.

I have one doubt about Denmark space organization.

Can you please help me?

I want to know, if is there a danish space agency or a danish space office?

With my best regards,

Izabella

office <office@space.dtu.dk> escreveu no dia quarta, 17/10/2018 à(s) 15:38:

> Hi Izabella
>
> At DTU Space (National Space Institute, Technical University of Denmark) we are 150 employees.
>
> Kind regards,
>
> **Lene Bettenhaus**
>
> Ledelsessekretær
>
> DTU Space
>
> ---
>
> **Danmarks Tekniske Universitet**
>
> Institut for Rumforskning og Rumteknologi
>
> Elektrovej
>
> Bygning 328, Rum 132
>
> 2800 Kgs. Lyngby
>
> Direkte telefon 45259502
>
> lene@space.dtu.dk
>
> www.dtu.dk
>
> **Fra:** Izabella Hemprich [mailto:izabella.hemprich@sim.ul.pt]
> **Sendt:** 15. oktober 2018 15:30
> **Til:** office
> **Emne:** Re: Information regarding Space business in Denmark
>
> Dear Lene Bettenhaus,
>
> Thank you for the answer.
> I just want to know about your institute, DTU Space.
>
> With kind regards,
>
> Izabella

office <office@space.dtu.dk> escreveu no dia segunda, 15/10/2018 à(s) 14:23:

> Dear Izabella
>
> If you need the total number of employees in Denmark working on space programs you need to contact our Ministry.
>
> There are several firms and institutes.
>
> If you only need the number from our institute, DTU Space, please let me know.
>
> Kind regards,
>
> **Lene Bettenhaus**
>
> Ledelsessekretær
>
> DTU Space
>
> ---
>
> **Danmarks Tekniske Universitet**
>
> Institut for Rumforskning og Rumteknologi
>
> Elektrovej
>
> Bygning 328, Rum 132
>
> 2800 Kgs. Lyngby
>
> Direkte telefon 45259502
>
> lene@space.dtu.dk
>
> www.dtu.dk
>
> **Fra:** Izabella Hemprich [mailto:izabella.hemprich@sim.ul.pt]
> **Sendt:** 15. oktober 2018 14:39
> **Til:** office
> **Emne:** Information regarding Space business in Denmark
>
> Dear Sir or Madam,
>
> I´m a research engineer and now i´m finishing my master thesis in applied mathematics.
> My tesis is a study regarding how ESA ITT´s is correlated with countries, expertises and other variables.
> I´m studying all ITT´s since 2013.
> Now, I´m studying how ESA awarded ITTs are correlated with the number of human resources that each space office has.
> I want to ask you, if is it possible to provide me oficial information regarding the number of employees are working full time for Space programs in Denmark (Can be the number of employees you have at your space office)?
> If you have any doubt, please feel free to contact me.
>
> With best regards,
>
> --
>
> Izabella Hemprich
>
> Control Engineer and Msc Student in Applied Mathematics
>
> FCUL,CENTRA-SIM group
>
> email: izabella.hemprich@sim.ul.pt

> skype: izabella_hemprich
>
> phone: 351 217500000 - ext: 28136
>
> FCUL web site: http://www.fc.ul.pt/
>
> CENTRA-SIM web site: http://centra.tecnico.ulisboa.pt/network/sim/

--

Izabella Hemprich

Control Engineer and Msc Student in Applied Mathematics

FCUL,CENTRA-SIM group

email: izabella.hemprich@sim.ul.pt

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phone: 351 217500000 - ext: 28136

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--

Izabella Hemprich

Control Engineer and Msc Student in Applied Mathematics

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FCUL web site: http://www.fc.ul.pt/

CENTRA-SIM web site: http://centra.tecnico.ulisboa.pt/network/sim/

Gmail by Google

Izabella Hemprich <izabella.hemprich@sim.ul.pt>

RE: Information regarding Space business in Estonia

Tiiu Treier <Tiiu.Treier@eas.ee> 15 de outubro de 2018 às 14:56
Para: "izabella.hemprich@sim.ul.pt" <izabella.hemprich@sim.ul.pt>

Dear Izabella Hemprich

We have two FTE at the Space Office in Estonia. You can find a short overview of us from here https://www.eas.ee/teenus/estonian-space-office/?lang=en .

Best regards

Tiiu Treier

Project Manager

Trade Development Agency

Enterprise Estonia

Lasnamäe 2, 11412, Tallinn, Estonia

Mob: +372 5660 1336

Tel: +372 627 9404

Tiiu.Treier@eas.ee

EAS Enterprise Estonia

www.eas.ee

www.facebook.com/EnterpriseEstonia

estonian space office

https://www.eas.ee/teenus/estonian-space-office/?lang=en

From: Izabella Hemprich <izabella.hemprich@sim.ul.pt>
Sent: Monday, October 15, 2018 3:43 PM
To: Info eas <Info@eas.ee>
Subject: Information regarding Space business in Estonia

Dear Sir or Madam,

I´m a research engineer and now i´m finishing my master thesis in applied mathematics.
My thesis is a study regarding how ESA ITT´s is correlated with countries, expertises and other variables.
I´m studying all ITT´s since 2013.
Now, I´m studying how ESA awarded ITTs are correlated with the number of human resources that each space office has.
I want to ask you, if is it possible to provide me official information regarding the number of employees are working full time for Space programs in Estonian Space Office?
If you have any doubt, please feel free to contact me.

With best regards,

--

Izabella Hemprich

Control Engineer and Msc Student in Applied Mathematics

FCUL,CENTRA-SIM group

email: izabella.hemprich@sim.ul.pt

skype: izabella_hemprich

phone: 351 217500000 - ext: 28136

FCUL web site: http://www.fc.ul.pt/

CENTRA-SIM web site: http://centra.tecnico.ulisboa.pt/network/sim/

Estonian Space Office

Eesti Kosmosebüroo (https://www.eas.ee/teenus/eesti-kosmoseburoo/?lang=et)

Open

Target group: **Estonian companies having competence, motivation, and capability (including start-up companies).**

Enterprise Estonia is the developer of the Estonian space policy and space business, and it promotes international cooperation, providing Estonian companies with new business opportunities on markets contributing to high technology.

Estonia has been a full member of the European Space Agency (ESA) since 2015.

Estonian Space office:

- mediates the invitations to tender of ESA
  (Participation in the invitations to tender of ESA enables Estonian companies and research institutions to successfully participate in the European Space Agency projects, thereby helping to bring new high-tech jobs to Estonia. It also creates prerequisites for the development of science-intensive products and services with high added value that are internationally competitive.)
- consults the project developers
- organises information days, seminars, conferences, study trips, and match-making events

Enterprise Estonia does not financially support the preparation of projects.

Euroopa Liit
Euroopa
Regionaalarengu Fond

Eesti
tuleviku heaks

Goal
To contribute to the readiness of Estonian companies and research institutions to participate in the invitations to tender of ESA, and to be successful in institutional export.

Results
The volume of contracts related to the space sector increases by 20% per year.

Estonian companies operating in the field of space can be found here: https://estonia.ee/companies-tags/smart-space-technology-and-applications/ (https://estonia.ee/companies-tags/smart-space-technology-and-applications/)

Information on how to create a company in Estonia can be found here: https://e-resident.gov.ee/ (https://e-resident.gov.ee/)

Participation

To participate in the programme, please contact the Estonian Space Office

Madis Võõras
Madis.Vooras@eas.ee (mailto:Madis.Vooras@eas.ee)
627 9795

Tiiu Treier
Tiiu.Treier@eas.ee (mailto:Tiiu.Treier@eas.ee)
6279404

Gmail by Google

Izabella Hemprich <izabella.hemprich@sim.ul.pt>

RE: Mail du site cnes.fr

contact_cnes.fr <contact@cnes.fr> 23 de outubro de 2018 às 15:17
Para: Hemprich <izabella.hemprich@sim.ul.pt>

Dear Madam,

Thank you for the interest in our website and in our company.

You can find these figures in our annual report 2017, at this address on our website : https://cnes.fr/fr/le-cnes/le-cnes-en-bref/rapport-annuel-2017

Best regards,

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

Direction de la Communication

18 avenue Edouard Belin 31401 Toulouse Cedex 9

contact@cnes.fr

cnes.fr

De : Hemprich <izabella.hemprich@sim.ul.pt>
Envoyé : dimanche 14 octobre 2018 16:04

Objet : Mail du site cnes.fr

Soumis le Dimanche, 14 Octobre, 2018 - 16:04 Soumis par l'utilisateur : Contenu du message : Vous

Nom Hemprich

Prénom Izabella

Adresse FCUL -Campo Grande - Edificio C8-Piso 1- Gabinete 36-Departamento de Física

Code postal 1749-016

Ville Lisboa

Pays Portugal

Email izabella.hemprich@sim.ul.pt

Contenu de votre message

Votre commentaire concerne Rubrique "Le CNES"

Votre commentaire concerne en particulier la page (Url) http://centra.tecnico.ulisboa.pt/network/sim/

Message

Dear Sir or Madam,

I´m a research engineer and now i´m finishing my master thesis in applied mathematics.
My tesis is a study regarding how ESA ITT´s is correlated with countries, expertises and other variables.
I´m studying all ITT´s since 2013.
Now, I´m studying how ESA awarded ITTs are correlated with the number of human resources that each space office has.

I want to ask you, if is it possible to provide me oficial information regarding the number of French Space Agency employees?
If you have any doubt, please feel free to contact me.

With best regards,

--
Izabella Hemprich
Control Engineer and Msc Student in Applied Mathematics
FCUL,CENTRA-SIM group
email: izabella.hemprich@sim.ul.pt
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CENTRA-SIM web site: http://centra.tecnico.ulisboa.pt/network/sim/

RAPPORT D'ACTIVITÉ 2017
ANNUAL REPORT 2017

cnes
CENTRE NATIONAL
D'ÉTUDES SPATIALES

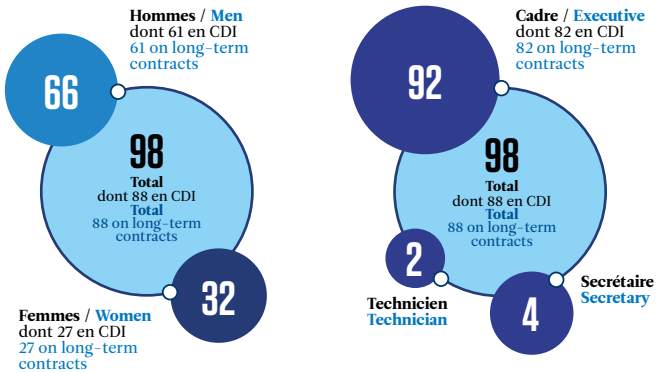
UNE POLITIQUE RH D'EXCELLENCE

THE PURSUIT OF EXCELLENCE

Le CNES s'appuie sur près 2 500 femmes et hommes dont les compétences sont forgées par l'excellence et le partage de valeurs communes, ainsi que sur un fort engagement social et environnemental. Parmi eux, une majorité d'ingénieurs et cadres (70 %) et de femmes (37 %). Cette politique se fonde sur une gestion des ressources humaines privilégiant la mobilité interne et la formation, afin d'accroître et d'optimiser les compétences de chacun. Elle met en œuvre des principes éthiques et de bonne gouvernance : développement d'un management responsable, promotion de la diversité et de la mixité, meilleure articulation entre vie professionnelle et vie personnelle et maintien d'un bon niveau de dialogue social.

The lifeblood of CNES is the 2,500 people whose talents are forged by excellence and shared values, together with a strong social and environmental commitment. Of these, 70% are engineers and executives, and 37% are women. The agency's human resources strategy is based on a management approach fostering internal mobility and training in order to increase and optimize our skills base. It applies the principles of ethical business conduct and good governance, through a responsible management approach, promotion of diversity and gender balance, an optimized work-life balance and a high level of social dialogue.

LES RECRUTEMENTS 2017 / Recruitment in 2017



94 %

des recrutements concernent des Ingénieurs et cadres.

Of new hires are engineers and executives.

2 386,1

Effectif moyen en équivalent temps plein (ETP)

Mean headcount, full-time equivalent (FTE).

Pauline Leblan,

Correspondante Ressources humaines, Siège du CNES à Paris

Human Resources correspondent, CNES Head Office, Paris

« C'est à l'occasion de la réorganisation de la Direction des Ressources Humaines début 2017 que j'ai été embauchée. Diplômée d'un Master 2 en Ressources Humaines, mes 8 ans d'expérience sur des missions RH opérationnelles et notamment en mobilité interne, ont intéressé le CNES pour lequel j'avais déjà fait une période d'intérim sur le même poste que j'occupe actuellement. J'accompagne les collaborateurs et managers de trois directions fonctionnelles du CNES dans l'évolution de leur parcours professionnel et les aide à développer leurs compétences. J'ai un rôle de conseil et d'orientation aux côtés des collaborateurs qui cherchent à changer de service ou de lieu de travail ou qui sont encouragés à le faire. »

"I was hired at the start of 2017 when the Human Resources directorate was reorganized. My Master's 2 degree in Human Resources and eight years' experience working on operational HR missions, focused notably on internal mobility, interested CNES where I'd already completed a temp assignment in the same post I occupy now. I help employees and managers in the agency's three functional directorates to manage their careers and develop their skills. My role is to advise and guide employees who are looking to or being encouraged to change jobs or their place of work."

Gmail by Google

Izabella Hemprich <izabella.hemprich@sim.ul.pt>

DLR personnel figures

Daniel.Beckmann@dlr.de <Daniel.Beckmann@dlr.de> 26 de outubro de 2018 às 12:09
Para: izabella.hemprich@sim.ul.pt

Dear Ms Hemprich,

here are the figures (as of September 2017) that might be of interest for you:

Total number of employees: 8.127 (2.587 female)
Non-scientific staff: 3.404 (50.7 % female)
Scientific staff: 4.723 (18.2 % female)
Average age: 40 years

PhD candidates: 969
Trainees: 237
Student interns: 440

Best regards

Daniel Beckmann

_____
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)
German Aerospace Center
Public Affairs and Communications | Linder Hoehe | 51147 Cologne | Germany

Daniel Beckmann | Editor Digital Media | Corporate Design
Telephone +49 2203 601-2466 | Mobile +49 174 3270300 | daniel.beckmann@dlr.de
DLR.de

-----Ursprüngliche Nachricht-----
Von: izabella.hemprich@sim.ul.pt [mailto:izabella.hemprich@sim.ul.pt]
Gesendet: Freitag, 26. Oktober 2018 12:43
An: Mittelbach, Elisabeth
Betreff: Allgemein

IP : 172.21.177.129
Ursprungs-URL: https://www.dlr.de/rd/desktopdefault.aspx/tabid-2096/
subject : Allgemein
Betreff : Information about DLR
Nachricht : Dear Sir or Madam,

I already sent this form about 2 weeks ago, and didn´t receive an answer.
Sorry for send again the same question.
"
I´m a research engineer and now i´m finishing my master thesis in applied mathematics.
My thesis is a study regarding how ESA ITT´s is correlated with countries, expertises and other variables.
I´m studying all ITT´s since 2013.
Now, I´m studying how ESA awarded ITTs are correlated with the number of human resources that each space office has.
I want to ask you, if is it possible to provide me oficial information regarding the number of DLR employees?
If you have any doubt, please feel free to contact me.

With best regards,

--
Izabella Hemprich
Control Engineer and Msc Student in Applied Mathematics
FCUL,CENTRA-SIM group
email: izabella.hemprich@sim.ul.pt
skype: izabella_hemprich
phone: 351 217500000 - ext: 28136
FCUL web site: http://www.fc.ul.pt/
CENTRA-SIM web site: http://centra.tecnico.ulisboa.pt/network/sim/
Vorname : Izabella
Name : Hemprich
Email : izabella.hemprich@sim.ul.pt
chkAgree : yes

Gmail by Google

Izabella Hemprich <izabella.hemprich@sim.ul.pt>

RE: Contact Us Request Received: - Information about Irish Space Office

Tony McDonald <Tony.McDonald@enterprise-ireland.com> 22 de outubro de 2018 às 14:57
Para: "izabella.hemprich@sim.ul.pt" <izabella.hemprich@sim.ul.pt>

Dear Izabella

To respond to your request , at present there is no formal space office in Ireland. Responsibilities for ESA membership and associated space activities are currently primarily dealt with by the Department of Business Enterprise and Innovation (DBEI) and Enterprise Ireland. The number of individuals engaged in these activities, between the two organizations is 5. However these individuals may allocate some of their time to non ESA/Space activities, from time to time

I hope this answers your question

Best Regards

Tony

From: NicantSithigh, Aisling
Sent: Monday 15 October 2018 14:35
To: izabella.hemprich@sim.ul.pt
Cc: McDonald, Tony <Tony.McDonald@enterprise-ireland.com>
Subject: RE: Contact Us Request Received: - Information about Irish Space Office

Thank you for your email which I am forwarding to Tony McDonald

Regards / le dea-mhéin

Aisling nic an tSithigh

e-mail / ríomhphost aisling.nicantsithigh@enterprise-ireland.com

www.enterprise-ireland.com

The Plaza / East Point Business Park / Dublin 3 / Ireland

An Plaza / Páirc Ghnó Na Rinne Thoir / BAC 3 / Eireann

From: noreply@ptools.com <noreply@ptools.com>
Sent: Monday 15 October 2018 14:12
To: Client Service <Client.Service@enterprise-ireland.com>
Cc: NicantSithigh, Aisling <Aisling.NicantSithigh@enterprise-ireland.com>
Subject: Contact Us Request Received: - Information about Irish Space Office

Contact Us Request Received

Name: Izabella Hemprich

Email: izabella.hemprich@sim.ul.pt

Phone: (351)915528921

Comment: I´m a research engineer and now i´m finishing my master thesis in applied mathematics. My thesis is a study regarding how ESA ITT´s is correlated with countries, expertises and other variables. I´m studying all ITT´s since 2013. Now, I´m studying how ESA awarded ITTs are correlated with the number of human resources that each space office has. I want to ask you, if is it possible to provide me official information regarding the number of employees are working full time for Space programs in Irish Space Office? If you have any doubt, please feel free to contact me. With best regards, -- Izabella Hemprich Control Engineer and Msc Student in Applied Mathematics FCUL,CENTRA-SIM group email: izabella.hemprich@sim.ul.pt skype: izabella_hemprich phone: 351 217500000 - ext: 28136 FCUL web site: http://www.fc.ul.pt/ CENTRA-SIM web site: http://centra.tecnico.ulisboa.pt/network/sim

Processed: 15/10/2018 14:12:12

Gmail by Google

Izabella Hemprich <izabella.hemprich@sim.ul.pt>

Information regarding ASI

3 mensagens

Izabella Hemprich <izabella.hemprich@sim.ul.pt> 14 de outubro de 2018 às 14:53
Para: urp@asi.it

Dear Sir or Madam,

I´m a research engineer and now i´m finishing my master thesis in applied mathematics.
My tesis is a study regarding how ESA ITT´s is correlated with countries, expertises and other variables.
I´m studying all ITT´s since 2013.
Now, I´m studying how ESA awarded ITTs are correlated with the number of human resources that each space office has.
I want to ask you, if is it possible to provide me oficial information regarding the number of Italian Space Agency employees?
If you have any doubt, please feel free to contact me.

With best regards,

--
Izabella Hemprich
Control Engineer and Msc Student in Applied Mathematics
FCUL,CENTRA-SIM group
email: izabella.hemprich@sim.ul.pt
skype: izabella_hemprich
phone: 351 217500000 - ext: 28136
FCUL web site: http://www.fc.ul.pt/
CENTRA-SIM web site: http://centra.tecnico.ulisboa.pt/network/sim/

URP <urp@asi.it> 16 de outubro de 2018 às 08:18
Para: Izabella Hemprich <izabella.hemprich@sim.ul.pt>

Dear Izabella,

ASI employees are 237.

You can find useful information on this topic on our Triennial Activity Plan, here: https://www.asi.it/sites/default/files/attach/dettaglio/022_-_pta_2017-2019_-_pta_2017-2019_finale2.pdf, pages 115-129.

We are sorry, but this plani s only in Italian.

Kind regards,

ASI Public Relations Office

Agenzia Spaziale Italiana

Unità Relazioni Esterne e URP

Via del Politecnico snc - 00133 Roma

Tel. +39 06 8567 237
Fax +39 06 8567 322

E-mail: urp@asi.it
PEC: urp_asi@asi.postacert.it

Web: www.asi.it www.asitv.it

Facebook: www.facebook.com/agenziaspazialeitaliana

Twitter: www.twitter.com/ASI_spazio

Da: Izabella Hemprich <izabella.hemprich@sim.ul.pt>
Inviato: domenica 14 ottobre 2018 15:54
A: URP <urp@asi.it>
Oggetto: Information regarding ASI

[Citação ocultada]

Izabella Hemprich <izabella.hemprich@sim.ul.pt> 16 de outubro de 2018 às 10:40
Para: urp@asi.it

Dear All,

Thank you very much for the information!
It is very important for my thesis.
No problem the document is in italian!

With kind regards,

Izabella
[Citação ocultada]

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2 anexos

image001.jpg
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image001.jpg
7K

Gmail by Google

Izabella Hemprich <izabella.hemprich@sim.ul.pt>

Information Polish Space Agency

Urszula Szwed-Strych <Urszula.Szwed-Strych@polsa.gov.pl> 17 de outubro de 2018 às 09:06
Para: "izabella.hemprich@sim.ul.pt" <izabella.hemprich@sim.ul.pt>
Cc: Sekretariat <sekretariat@polsa.gov.pl>

Dear Ms Hemprich,

thank you for your interest in POLSA.

Responding to your question - the Polish Space Agency currently employs 48 people.

Should you have any more questions regarding POLSA please do not hestitate to contact me directly.

Z poważaniem/

Best regards

Urszula Szwed-Strych

Główny Specjalista ds. Kontaktów z Mediami/

Chief Specialist for Media Relations

tel.: +48 516 222 671

tel.: +48 22 380 01 51

POLSKA AGENCJA KOSMICZNA

Polska Agencja Kosmiczna

ul. Trzy Lipy 3

80-172 Gdańsk

Oddział Terenowy w Warszawie

ul. Powsińska 69/71

02-903 Warszawa

NIP: 957-107-74-43

REGON: 360992221

www.polsa.gov.pl

Facebook/PolskaAgencjaKosmicznaPOLSA

From: Izabella Hemprich [mailto:izabella.hemprich@sim.ul.pt]
Sent: Sunday, October 14, 2018 4:25 PM
To: Sekretariat <sekretariat@polsa.gov.pl>
Subject: Information Polish Space Agency

[Citação ocultada]

Gmail by Google

Izabella Hemprich <izabella.hemprich@sim.ul.pt>

Fwd: Information about INTA

José Gabriel Carrión Martín <carrionmj@inta.es> 26 de outubro de 2018 às 11:23
Para: Izabella Hemprich <izabella.hemprich@sim.ul.pt>

Dear Mrs. Hemprich,

Sorry for not having answered before.

About your consultation, current number of INTA employees is around 2000, but not all of them are scientific-technical devoted. Roughly speaking, 1200 of them can be dedicated to direct scientific-technical activities.

I hope I had answered your question.

Best regards,

José G. Carrión

INTA - Spanish Ministry of Defence

Area for Scientifical, Technical and Commercial Cooperation

carrionmj@inta.es

De: Izabella Hemprich [mailto:izabella.hemprich@sim.ul.pt]
Enviado el: domingo, 14 de octubre de 2018 16:20
Para: José Gabriel Carrión Martín
Asunto: Fwd: Information about INTA

[Citação ocultada]

Gmail by Google

Izabella Hemprich <izabella.hemprich@sim.ul.pt>

Information Request

1 mensagem

Izabella Hemprich <izabella.hemprich@sim.ul.pt> 13 de março de 2017 às 12:43
Para: Stefano.Fiorilli@esa.int

Dear Mr. Stefano M. Fiorilli

I hope you are fine.

My name is Izabella Hemprich, and I am a researcher engineer and master student in applied mathematics at Faculty of Sciences of the University of Lisbon in Portugal, where I work in the CENTRA/SIM group.

My master thesis will focus in a study of data clustering. One of the objectives is to study the clusters of the winner consortia of each ITT from the ESA dashboards, and try to correlate them in areas of knowledge, expertise and also to relate them with the ESA center that issued the ITT (ESTEC, ESOC, HQ, etc.) and other parameters available in the call.

The data that I intend to use is provided by the ESA Dashboards (public domain), that I receive every time is published (but if you have any further suggestion of dataset I would also appreciate a lot!). For my thesis it is important to consider a large amount of data, and thus to use the ESA Dashboards from the last five years at least. Nevertheless, I only have data from 2016. Thus, I would like to ask you if it would be possible to have access to the Dashboard files from 2011 until the end of 2016. Do you think this would be possible?

I thank you in advance for any data you could provide!

Best regards,

–
Izabella Hemprich
Researcher at FCUL, in CENTRA-SIM group
email: izabella.hemprich@sim.ul.pt
skype: izabella_hemprich
phone: 351217500742
FCUL web site: http://www.fc.ul.pt/
CENTRA-SIM web site: http://centra.tecnico.ulisboa.pt/network/sim/

Gmail by Google

Izabella Hemprich <izabella.hemprich@sim.ul.pt>

Information Request - ESA Procurement Dashboards

1 mensagem

Ingrid.Oppenheimer@esa.int <Ingrid.Oppenheimer@esa.int> 16 de março de 2017 às 09:06
Para: izabella.hemprich@sim.ul.pt

Dear Ms. Hemprich,

Mr. Fiorilli, Head of ESA Procurement Department, has forwarded to me the email you had sent to him on 13 March with a request for information related to the ESA Dashboards.

Please be advised that the first Dashboard was published in December 2013. The first 3 were posted on EMITS in pdf-format. I will include them for completion, but unfortunately I do not have these 3 in excel format.

ESA is using LotusNotes as its email tool. There is a limitation of data which we can send per individual email. Therefore, you will receive from me 3 more emails, containing zip-files of the dashboards from December 2013 up to December 2016.

Please let me know in case the data does not reach you correctly. I may need to further split the zip-files, due to the size of the data.

With kind regards,
Ingrid Oppenheimer

ESA - European Space Agency

Ingrid Oppenheimer
Head Procurement Planning & Support Office (IPL-PTC)
Procurement and EU Administration Department

ESTEC, The Netherlands
Keplerlaan 1, PO Box 299
NL-2200 AG Noordwijk
ingrid.oppenheimer@esa.int | www.esa.int
T +31 71 565 4010

(in the office Mon-Tue-Thu-Fri)

Gmail by Google

Izabella Hemprich <izabella.hemprich@sim.ul.pt>

Re: Information Request - ESA Procurement Dashboards (2016)

1 mensagem

Ingrid.Oppenheimer@esa.int <Ingrid.Oppenheimer@esa.int> 12 de junho de 2017 às 09:51
Para: Izabella Hemprich <izabella.hemprich@sim.ul.pt>

Dear Ms. Hemprich,

Please find below extract made by the IT support division, based on the example structure previously sent to you, with now the inclusion of the open (and closing) dates of the ITTs.

Please note that I have requested that they make the file from the first to the last ITT numbers in your request. This means that the intermediate numbers that you did not need are also included; I hope you don't mind to filter those out.

Kind regards,
Ingrid Oppenheimer

ESA - European Space Agency

Ingrid Oppenheimer
Head Procurement Planning & Support Office (IPL-PTC)
Procurement and EU Administration Department

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Keplerlaan 1, PO Box 299
NL-2200 AG Noordwijk
ingrid.oppenheimer@esa.int | www.esa.int
T +31 71 565 4010

(in the office Mon-Tue-Thu-Fri)

From: "Izabella Hemprich" <izabella.hemprich@sim.ul.pt>
To: Ingrid.Oppenheimer@esa.int
Date: 09/06/2017 12:42
Subject: Re: Information Request - ESA Procurement Dashboards (2016)

Dear Ms. Oppenheimer,

I´m really thankful for all support you are giving to me, and you can be sure that I will acknowledge all this help you and ESA are giving to my work.

The data that your IT support can provide is really good and fits perfectly to what I need to develop my master thesis.

Just one minor addition: is it possible for the IT support to include in the table you sent me the ITT open date? If not, it´s ok I will try to add it by hand.

The ITTs that I need the information from EMITS are in attachment.

With kind regards,

Izabella

2017-06-08 10:01 GMT+01:00 <Ingrid.Oppenheimer@esa.int>:
Dear Ms. Hemprich,

Please find below the file you sent, completed with the winner(s).

Regarding the information for the old ITTs, I have been in touch with our IT support division and they have sent me an example of an extract they could generate from the EMITS Archive:

If the content / structure is OK for you, please send me the list of ITTs and I will get back to the IT support division to generate the file.

Kind regards,
Ingrid Oppenheimer

ESA - European Space Agency

Ingrid Oppenheimer
Head Procurement Planning & Support Office (IPL-PTC)
Procurement and EU Administration Department

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Keplerlaan 1, PO Box 299
NL-2200 AG Noordwijk
ingrid.oppenheimer@esa.int | www.esa.int
T +31 71 565 4010

(in the office Mon-Tue-Thu-Fri)

From: "Izabella Hemprich" <izabella.hemprich@sim.ul.pt>
To: Ingrid.Oppenheimer@esa.int
Date: 18/05/2017 12:31
Subject: Re: Information Request - ESA Procurement Dashboards (2016)

Dear Ms. Oppenheimer,

I hope everything is doing fine with you!

Two months ago, you sent me all the ESA Dashboards since 2013 till 2016. During this time, I worked with all these dashboards and I managed to organize and consolidate them together in a single table.

However, I detected that the information in some of them is incomplete: There are some ITTs without indication of the winner. And this information is essential for my thesis.

The ITTs without information about the winner are in the attached XLS file. Is it possible to complete the winner field for me?

Another essential data for the development of my thesis work is the ESA EMITS public data for the contracts (e.g. the abstract of the ITTs). Since February, I am collecting all the published information, but in the oldest ITTs, this information is not available anymore. Do you think that it would be possible to retrieve this information if I send you a list of the ITTs that I need information about, or at least could you point me to anyone who could help me retrieving this public domain information?

Thanks you really a lot for all your help! It has been of great value to the development of my thesis!

With my best regards,

Izabella

Izabella Hemprich
Researcher at FCUL, in CENTRA-SIM group
email: izabella.hemprich@sim.ul.pt
skype: izabella_hemprich
phone: 351217500742
FCUL web site: http://www.fc.ul.pt/
CENTRA-SIM web site: http://centra.tecnico.ulisboa.pt/network/sim/

2017-03-17 8:39 GMT+00:00 <Ingrid.Oppenheimer@esa.int>:
Dear Ms. Hemprich,

You are welcome.

We wish you all the best with your master thesis.

Kind regards,
Ingrid Oppenheimer

ESA - European Space Agency

Ingrid Oppenheimer
Head Procurement Planning & Support Office (IPL-PTC)
Procurement and EU Administration Department

ESTEC, The Netherlands
Keplerlaan 1, PO Box 299
NL-2200 AG Noordwijk
ingrid.oppenheimer@esa.int | www.esa.int
T +31 71 565 4010

(in the office Mon-Tue-Thu-Fri)

From: "Izabella Hemprich" <izabella.hemprich@sim.ul.pt>
To: Ingrid.Oppenheimer@esa.int
Date: 16/03/2017 17:22
Subject: Re: Information Request - ESA Procurement Dashboards (2016)

Dear, Ms.Oppenheimer

I received all the dashboards.
Thanks a lot for the attention and quick answer.

Kind regards,

Izabella

2017-03-16 15:58 GMT+00:00 <Ingrid.Oppenheimer@esa.int>:
Dear Ms. Hemprich,

Please find attached zip-file for 2016.

Thank you and Regards,
Ingrid Oppenheimer

ESA - European Space Agency

Ingrid Oppenheimer
Head Procurement Planning & Support Office (IPL-PTC)
Procurement and EU Administration Department

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(in the office Mon-Tue-Thu-Fri)

From: "Izabella Hemprich" <izabella.hemprich@sim.ul.pt>
To: Ingrid.Oppenheimer@esa.int
Date: 16/03/2017 13:47
Subject: Re: Information Request - ESA Procurement Dashboards

---

Dear Ms.Oppenheimer

Thank you very much for the answer.
I will work with these available data that you will send me.
About the PDFs, there is no problem. You can send them anyway.
I´ll wait the emails, and any problem about the receipt, I´ll tell you.
Once again, thank you and please also say thanks to Mr. Fiorilli.

Kind Regards,

Izabella

--
Izabella Hemprich
Researcher at FCUL, in CENTRA-SIM group
email: izabella.hemprich@sim.ul.pt
skype: izabella_hemprich
phone: 351217500742
FCUL web site: http://www.fc.ul.pt/
CENTRA-SIM web site: http://centra.tecnico.ulisboa.pt/network/sim/

2017-03-16 12:06 GMT+00:00 <Ingrid.Oppenheimer@esa.int>:

Dear Ms. Hemprich,

Mr. Fiorilli, Head of ESA Procurement Department, has forwarded to me the email you had sent to him on 13 March with a request for information related to the ESA Dashboards.

Please be advised that the first Dashboard was published in December 2013. The first 3 were posted on EMITS in pdf-format. I will include them for completion, but unfortunately I do not have these 3 in excel format.

ESA is using LotusNotes as its email tool. There is a limitation of data which we can send per individual email. Therefore, you will receive from me 3 more emails, containing zip-files of the dashboards from December 2013 up to December 2016.

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With kind regards,
Ingrid Oppenheimer

ESA - European Space Agency

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(in the office Mon-Tue-Thu-Fri)

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Izabella Hemprich
Researcher at FCUL, in CENTRA-SIM group
email: izabella.hemprich@sim.ul.pt
skype: izabella_hemprich
phone: 351217500742
FCUL web site: http://www.fc.ul.pt/
CENTRA-SIM web site: http://centra.tecnico.ulisboa.pt/network/sim/

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--
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skype: izabella_hemprich
phone: 351217500742
FCUL web site: http://www.fc.ul.pt/
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--

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Please consider the environment before printing this email.

2 anexos

List of ITTs_ 2013_2014_2015_2016_rev1.xlsx
67K

EMITS_ITT_ARCHIVE.xlsx
923K